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ASSET-MARKET MODELS OF EXCHANGE-RATE
DETERMINATION: BASIC MODELS, EMPIRICAL
EVIDENCE AND EXTENSION*

Simón Sosvilla-Rivero

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Simón Sosvilla-Rivero

(Universidad Complutense and Ministry of Economy and Finance)

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INTRODUCTION

"...We maintain that the value of two moneys may diverge...because of scarcity and need. ...[other things being equal] in countries where there is a great scarcity of money all other saleable goods, and even the hands and labour of men, are given for less money than where it is abundant. Thus we see by experience that in France, where money is scarcer than in Spain, bread, cloth, and labour are worth much less... The reason for this is that money is worth more where and when it is scarce than where and when it is abundant". (Azpilcueta Navarro, 1556, p. 8; quoted from Grice-Hutchinson, 1952, pp. 91, 92, and 95).

"At the present stage of development in economics it is probably an advantage to have different groups look at the same problem from different viewpoints, so that their models and conclusions can be compared and possibly then form the basis for a new compressive model". (Granger, 1990, p. 1)

Since the adoption of relatively free floating exchange rates in the early 1970s, the world has witnessed extreme volatility in bilateral exchange rates and large and persistent international payments imbalances which have made the understanding of the foreign exchange market of central importance.

The search for an acceptable model to explain the movement of the nominal exchange rate in terms of other macroeconomic variables has led to an extensive literature on exchange rate modelling. This theoretical literature does not rest on a fully specified macroeconomic framework that captures all the major exchange rate influences and transmission mechanisms, attention being focused on certain relationships while excluding others.

In contrast with the "traditional flow" model, which focuses on the

demand and supply flows in the foreign exchange market, a new class of macroeconomic models have been proposed to explain movements in exchange rates during the recent experience with a regime of flexible exchange rates (or more precisely, a regime of managed float). They are the asset market models. In their analytical framework, exchange rate behavior is looked at from the point of view of its role in clearing relative demands for stocks of domestic and foreign assets rather than in terms of clearing international trade flows of goods and services -emphasis is therefore put on the capital account of the balance of payments rather than on the current account. Within the asset market approach, two kind of models can be distinguished. One is the "monetary" model, which looks solely at the supply and the demand for money in each country. The other is the "portfolio-balance" model, which extends the analysis explicitly to include other assets.

This paper considers the theoretical derivation of the reduced-form exchange rate equations which are representative of this kind of models, their econometric reduced-form empirical evidence for the 1970s and 1980s, and some extensions of the basic models.

The paper is organized as follows. Section 1 briefly discusses the traditional flow model for comparative purposes. In Sections 2 and 3 we develop the basic asset-models of exchange-rate determination: the monetary model (in both its flexible-price and sticky-price versions) and the portfolio-balance models, respectively. Sections 4 and 5 examine the evidence relating to various formulations of those models, as well as discuss some theoretical extensions of such models (which have previously remained dispersed) in an attempt to improve their performance. Section 6 considers the synthesis of the monetary and portfolio approaches to exchange-rate determination. In Section 4 we examine the evidence on the predictive performance of some asset-market models. Section 7 studies the role of the "news" in exchange rate determination. In the concluding section we summarize the salient findings in the literature.

1.-THE TRADITIONAL FLOW MODEL.

The traditional flow model (TFM) has a long tradition in international economics, dating back to the contributions of Harberger (1950), Laursen and Metzler (1950), Machlup (1955), and Meade (1951). This approach was then further developed by the writings of Fleming (1962), Johnson (1958), McKinnon and Oates (1966), Mundell (1968), Pearce (1961), and Tsiang (1961), to name but a few.

In the simplest version of the model (the balance-of-payments model), the exchange rate is viewed as the price which brings into equilibrium the supply of and the demand for domestic currency payments arising from international trade of goods, services and financial assets. The model can be formulated with the help of equation (1.1):

$$\text{BOP} = T(SP^*/P, Y/Y^*) - C(i - i^*) = 0, \quad (1.1)$$

where the service account is ignored for the sake of expositional simplicity. BOP denotes the balance of payments. T is the trade balance (or net exports), which is assumed to be determined by the relative price of foreign goods in terms of domestic goods, SP^*/P , and the relative income levels at home and abroad, Y/Y^* ; where S is the exchange rate (defined as the domestic currency price of foreign exchange), P is the price level, Y is real income, and an asterisk denotes a foreign variable. The capital account is represented by C, with a positive value of C associated with net a capital outflow (i. e., a net purchase of foreign bonds). C depends on the interest rate differential $(i - i^*)$. Domestic and foreign bonds are assumed to share the same characteristics in terms of liquidity, maturity, default risk, political risk, etc. In addition, it is assumed that there are no anticipated exchange rate changes.

Equation (1.1) simply states that the sum of the current and capital accounts of the balance of payments must, with a floating exchange rate, be zero (that is, any current-account imbalance is just matched by a net capital flow in the opposite direction).

With the exchange rate assumed to clear the foreign exchange market, equation (1.1) can be solved for S to yield

$$S = S(Y/Y^*, P/P^*, i-i^*) \quad (1.2)$$

Therefore, in this framework the exchange rate depends on the relative levels of income at home and abroad, relative price levels and the interest-rate differential. We will expect the following partial derivatives: $S_Y > 0$, $S_P > 0$, and $S_i < 0$. An increase in domestic income relative to foreign income (because of, say, an autonomous increase in spending) will worsen the current account and thus require an offsetting depreciation of the exchange rate; an increase in domestic prices relative to foreign prices leads to a precisely offsetting depreciation; finally, an increase in the interest-rate differential leads to an appreciation.

The model posits various degrees of substitution between foreign and domestic assets, from zero capital mobility to the Mundellian assumption of perfect capital mobility (namely, that interest rates must be the same at home and abroad). An increase in the domestic interest rate, with no change in the foreign interest rate, is predicted to cause a net capital inflow that results in an appreciation of the exchange rate.

The role of capital flows in the determination of exchange rates highlighted by the balance-of-payments model is also adopted by the influential analysis that was originated with the pathbreaking series of articles by Robert Mundell and John Marcus Fleming in the early 1960s (see Mundell, 1962, 1963; and Fleming, 1962). They incorporate the balance-of-payments equation (1.1) into the macroeconomic framework of interest rate and output determination, arguing that changes in exchange rates affect competitiveness.

The so-called Mundel-Fleming model for a small open economy can be expressed by means of the following equations:

$$M/P = L(Y, i), \quad (1.3)$$

$$Y = E(Y, i) + T(SP^*/P, Y/Y^*), \quad (1.4)$$

$$BOP = T(SP^*/P, Y/Y^*) + C(i - i^*) = 0, \quad (1.5)$$

where M is the nominal quantity of money. Equation (1.3) is the money-market equilibrium equation, equating supply of and demand for real balances. Money demand depends negatively on the interest rate and positively on a transaction variable, proxied by domestic output. Equation (1.4) is the goods-market equilibrium equation. Domestic private absorption (expressed in terms of domestic goods) plus the trade balance surplus (expressed in terms of domestic output) equals domestic production. Private absorption depends on income and the interest rate. Equation (1.5) reproduces the balance-of-payments equation (1.1).

There is no equation for labour market equilibrium since nominal wages and prices are kept fixed. By Walras's Law, if the economy is in equilibrium [as expressed in equations (1.3) to (1.5)], it will necessarily imply that the domestic bondsmarket is also in equilibrium.

Given Y and i , the exchange rate is determined by the goods market at the value which sets $T=Y-E$. Thus from the goods-market equilibrium condition (1.4) we obtain the following expression for the exchange rate

$$S = S'(i, Y/Y^*, P/P^*). \quad (1.6)$$

The model is illustrated in Figure 1.1 for the case of perfect capital mobility and static expectations, which imply $i=i^*$ ¹. In Figure 1.1 we plot a domestic goods-market equilibrium curve (IS), a domestic-money market equilibrium curve (LM), a trade-balance equilibrium curve (BT), a capital flow function (FE), and a domestic-income-equals-domestic-expenditure curve (YY).

¹ See Laffer and Miles (1982, Ch. 16) for a diagrammatical exposition of the Mundell-Fleming model under different degrees of capital mobility. See also Branson and Bulters (1983) and Winters (1985) for the case of rational expectations.

The predicted effects of changes in the exogenous variables on the exchange rate are as follows:

□ An increase in Y^* . This case can be illustrated in Figure 1.2. The initial equilibrium is at Q_0 . An increase in foreign real income changes exports and shifts the IS and BT curves to the right to $I'S'$ and $B'T'$. They necessarily intersect along the line YY . Since the LM curve has not changed, the equilibrium moves from Q_0 to Q_1 . At point Q_1 there is an incipient balance-of-payments surplus, therefore the exchange rate appreciates. The fall in S shifts the $I'S'$, FE and $B'T'$ curves to the left to IS, FE and BT (the shift to the left of the FE curve leaves it unchanged, since it is horizontal). The final equilibrium, therefore, is at point Q_0 . The expansionary effect of the increase in foreign real income is completely offset by the fall in S .

□ An increase in P^* . The effects of an increase in the foreign price level can also be illustrated in Figure 1.2. An increase in P^* shifts the IS and BT curves to the right to $I'S'$ and $B'T'$, their intersection moving along YY . With unchanged S , the goods market and money market are in equilibrium at Q_1 . At this point, however, there is an incipient balance-of-payments surplus. Consequently, the exchange rate appreciates (i. e., S falls), shifting $I'S'$, FE and $B'T'$ to the left to IS, FE and BT. The final equilibrium is at Q_0 .

□ An increase in i^* . Figure 1.3 illustrates this case. An increase in the interest rate abroad shifts the FE curve upwards to $F'E'$. At the initial equilibrium, Q_0 , there is an incipient balance-of-payments deficit, so S increases (depreciates), shifting the IS, $F'E'$ and BT to the right to $I'S'$, $F'E'$ and $B'T'$. The equilibrium is now at Q_1 .

□ Changes in domestic variables have symmetrical effects. An increase in domestic real income or in domestic price level leads to an exchange-rate depreciation.

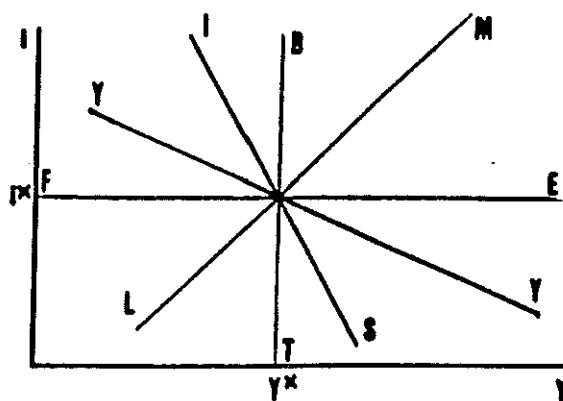


Figure 1.1. MFM with perfect capital mobility.

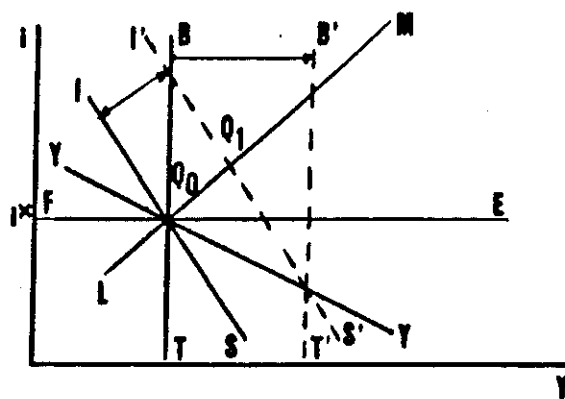


Figure 1.2. MFM: An increase in Y^* or an increase in P^* .

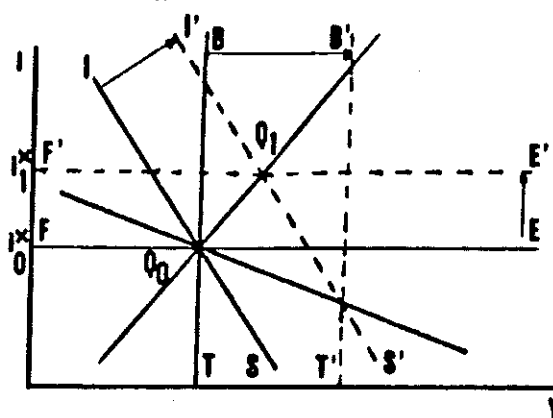


Figure 1.3. MFM: An increase in i^* .

The Mundell-Fleming model has been the focus of a number of critical attacks, some of them fundamental. The main theoretical criticism of the traditional flow model is directed at its implications for the asset market². The model predicts that an exchange rate could be in equilibrium when a country is running a current-account deficit if the domestic interest rate is high enough to maintain an offsetting net capital inflow. This implies that with a constant interest differential, there is a steady, potentially infinite accumulation of domestic assets by foreigners. No account is given of how the portfolios of foreigners are brought into equilibrium. It neglects the debt-service payments (and also the "crowding out" of domestic investment) associated with short-term capital inflows. Unless the current-account balance is restored to some sort of sustainable equilibrium, mounting foreign debt (or interest-income payments to foreigners) will aggravate future imbalances on current account.

Moreover, by emphasizing flows, this model neglects two types of relationships between stocks and flows. Firstly, it neglects accounting relationships, since international financial flows add to stocks of claims and liabilities; and secondly, it neglects behavioral relationships, since, *ceteris paribus*, the larger is a country's stock of claims on the outside world, the smaller will be the incentive to add to that stock (see Allen and Kenen, 1978; and Purvis, 1985).

Finally, the lack of any role for exchange-rate expectations, the nonexistence of spillover effects of depreciation into domestic prices, and the absence of any dynamics are pointed out by Dornbusch (1976) as further limitations of the traditional flow model³.

² For a criticism of the traditional flow model, see Mussa (1976).

³ Turnovsky (1977) extends the Mundell-Fleming model to allow for the dynamics stemming from the interaction between stocks and flows and to consider debt-service payments. The analysis, however, is conducted in an integrated model conceived to deal with broader issues, and not specifically devoted to the determination of the exchange rate.

2.-THE MONETARY MODELS.

Basically, the monetary approach to the analysis of exchange rates may be viewed as the counterpart to the monetary approach to the balance of payments. These approaches emphasize the role of money in determining the balance of payments under a regime of fixed exchange rates and in determining the exchange rate under a regime of flexible exchange rates. Their intellectual origins can be traced back to David Hume's writing on money, but the modern forms evolved from the contributions of Dornbusch, Frenkel, Johnson, Mundell, Mussa, Polak, and Swoboda, among others⁴.

Within the monetary approach to exchange rate determination, two models comprising different special assumptions may be distinguished:

- i) the "flexible-price" monetary model (FPMM), and
- ii) the "sticky-price" monetary model (SPMM).

Both have relative demands for and supplies of money as the principal determinant of exchange rates. Changes in the stock of other assets have no direct impact on the exchange rate⁵. Domestic and foreign assets are viewed as essentially perfect substitutes in investors' portfolios, and barriers to instantaneous adjustments of portfolios are assumed to be unexisting. If two assets are perfect substitutes, then their relative price is constant and they can be aggregated using the Hicks aggregation theorem, reducing the number of asset we need to consider in the models.

In contrast to the traditional flow model, in which the exchange rate is determined by trade and capital flows, these models assert that the equilibrium exchange rate depends on the stock-equilibrium

⁴ For details on the origins of the monetary approach to exchange-rate determination, see Frenkel (1976).

⁵ As Frenkel and Mussa (1985, p. 724) remark "changes in the stocks of alternative assets result in exchange rate changes only to the extent that they alter the various rates of return which affect the demand for money".

conditions in the money market of each country.

2.1.- THE FLEXIBLE-PRICE MONETARY MODEL.

2.1.1.-The Frenkel-Mussa-Bilson model⁶.

This model adopts three radically simplifying assumptions. First, it is assumed that money markets are continuously in equilibrium. The second assumption is that purchasing power parity holds and is expected to continue to do so; that is, it is assumed that all prices are perfectly flexible. The last assumption is that there is perfect capital mobility and that the risk premium is zero⁷; then, irrespective of relative asset supplies, the nominal interest-rate differential between foreign and domestic asset returns always equals the expected rate of appreciation of the domestic currency (i.e., uncovered interest rate parity holds), and asset holders are indifferent as to the composition of their portfolios between assets denominated in different currencies.

Consider first the equilibrium in the money market. Let us assume that the demand for money is of the Cagan (1956) functional form:

$$L_t = N Y_t^\phi \exp(-\lambda i_t),$$
$$L_t^* = N^* Y_t^{*\phi} \exp(-\lambda i_t^*),$$

where L is the stock of real balances demanded; Y is the level of real income; ϕ and λ represent the money demand elasticity with respect to income and the money demand semielasticity with respect to the interest rate, respectively; and N and N^* are parameters. Note that, for simplicity, we have assumed that the elasticities in the real-balance demands are identical between countries (i.e., $\phi = \phi^*$ and $\lambda = \lambda^*$; this

⁶ See Frenkel (1976), Mussa (1976), and Bilson (1978a, 1978b, 1978c).

⁷ This assumption requires either that wealth-holders are indifferent to exchange risks or, if they are risk averse, that exchange risks faced by creditors and debtors are usually offset and diversified away.

simplifying assumption, adopted in most empirical estimations to avoid multicollinearity, will be later relaxed).

The supplies of domestic and foreign real balances are M_t/P_t and M_t^*/P_t^* , where M and P denote the nominal money supply and the price level, respectively. Assuming instantaneous adjustment in the demand for real balances to changes in real income and nominal interest rates, equilibrium in the money market is attained when:

$$L_t = M_t/P_t,$$

and

$$L_t^* = M_t^*/P_t^*,$$

or, equivalently,

$$M_t/P_t = NY_t^\phi \exp(-\lambda i_t),$$

and

$$M_t^*/P_t^* = N^* Y_t^{*\phi} \exp(-\lambda i_t^*).$$

Taking logarithms in the above expressions we obtain

$$m_t - p_t = n + \phi y_t - \lambda i_t, \quad (2.1)$$

$$m_t^* - p_t^* = n^* + \phi y_t^* - \lambda i_t^*, \quad (2.2)$$

where lower-case variables denote logarithms (except the interest rates) and where $n = \log N$ and $n^* = \log N^*$.

From equations (2.1) and (2.2), the difference between the logarithm of domestic and foreign price levels may be expressed in terms of the logarithm of domestic and foreign money supplies and the logarithm of variables (other than prices) and parameters which enter the respective demand function for domestic and foreign money:

$$(p_t - p_t^*) = (n^* - n) + (m_t - m_t^*) - \phi(y_t - y_t^*) + \lambda(i_t - i_t^*). \quad (2.3)$$

Thus relative prices are influenced by relative movements in money supplies, income, and interest rates.

In its *absolute* version, PPP theory establishes a relationship between the exchange rate S (expressed as the home currency price of a unit of foreign exchange), and the ratio of domestic and foreign prices (P and P^* , respectively), so that

$$S_t = P_t / P_t^*,$$

or, taking logarithms,

$$s_t = (p_t - p_t^*). \quad (2.4)$$

Its implication is that the higher the domestic price level relative to the foreign price level, the higher must be the exchange rate in order to retain purchasing power parity between domestic and foreign currencies.

The uncovered interest-rate-parity assumption can be written as follows:

$$\Delta s_t^e = i_t - i_t^*, \quad (2.5)$$

where Δ denotes the difference operator (i. e., $\Delta x_t = x_t - x_{t-1}$) and s_t^e the natural logarithm of the expected exchange rate. Comparable interest bearing assets denominated in different currencies are assumed to be perfect substitutes, and both portfolio preferences and influences on supplies of interest-bearing assets such as bond-financed fiscal policy, sterilized intervention in the foreign exchange market, and current account imbalances lose any influence they might otherwise exert.

Combining (2.3) and (2.4), we obtain the following reduced-form equation of spot exchange rate determination:

$$s_t = (n^* - n) + (m_t - m_t^*) - \phi(y_t - y_t^*) + \lambda(i_t - i_t^*). \quad (2.6)$$

Note once more that in deriving equation (2.6) it is assumed that the domestic demand for money has identical elasticities to those of the demand for domestic currency. This is the conventional formulation of the demand for money which implicitly asserts that domestic residents hold only domestic currency balances and residents abroad hold only foreign currency balances.

Equation (2.6) implies three testable hypotheses: (a) the coefficient on the relative money supply is positive and unity; (b) the coefficient on the relative real income term is negative; and (c) the coefficient on the relative interest rate is positive. Hence the partial effects of these variables are predicted as follows:

□ An increase in the domestic money supply, which results in an initial excess money supply, immediately drives prices up in the same proportion and hence, through the purchasing power parity condition, the exchange rate depreciates in that proportion.

□ An increase in domestic real income causes excess money demand that, with fixed money supply, results in a reduction in domestic prices and, through the purchasing power parity, leads to an exchange-rate appreciation.

□ An increase in the domestic interest rate, which is assumed to reflect higher expected inflation, lowers money demand, raises prices, and depreciates the exchange rate.

□ Changes in foreign variables have symmetrical effects. The domestic exchange rate is appreciated by a rise in foreign money supply, by a reduction in foreign real income, and by an increase in the foreign interest rate.

Note that, although the monetary approach focuses on monetary equilibrium, movements in real variables (e. g. changes in oil prices, net exports, or consumption and saving behavior) are reflected in the relative real income variable. If such movements affect real income, they will alter the level of money demand and have a predictable effect on the exchange rate. Note also that like the traditional flow model, the flexible-price monetary model predicts that changes in real income and interest rates affect the exchange rate. However, the effects are in the opposite direction, since the flexible-price monetary model asserts that rapid economic growth and a low interest rate should cause the exchange rate to appreciate. As Saville (1980) points out, the differences in predictions from the FPMM and the TFM come from the fact

that neither of the models is a fully specified general equilibrium model of the open economy.

Bilson (1979b) argues that the apparent conflict arising in the relationship between the exchange rate and the interest rate term may be resolved by a full specification of the determinants of the interest rate. In the monetary approach, capital markets are generally assumed to be fully integrated, so that nominal interest rate differentials reflect primarily differences in expected inflation rates or, through the purchasing power parity condition, expectation of a depreciation of the domestic currency. In contrast, the traditional flow approach assumes some degree of capital market segmentation, at least in the short run, so that monetary policy may have an independent influence on the real rate of interest. On the other hand, the conflict arising from the predictions about the effect of an increase in the level of real income on the exchange rate would require a specification of how the increase in the level of real income was brought about. The argument in the monetary approach is not that higher levels of real income will not create a current account deficit (as predicted by the traditional flow approach), but that any current account deficit will be dominated by an incipient capital account surplus brought about by the increase in the demand for money. Bilson (1979b) argues that the monetary model would appear to be correct if the increase in the level of real income was due to real factors, such as population growth, capital account developments, or debt financed government expenditure and that the traditional flow model would be correct if the central bank offsets the effect of higher real income on the capital account through a policy of monetary expansion.

An obvious problem with equation (2.6) is the presumed exogeneity of the interest differential. This assumption does not seem reasonable because of the high degree of integration between the securities and foreign exchange markets. By substituting (2.5) into (2.6), we solve this problem, expressing the exchange rate as follows:

$$s_t = (n^* - n) + (m_t^* - m_t) - \phi(y_t - y_t^*) + \lambda \Delta s_t^e. \quad (2.7)$$

Equation (2.7) states that the exchange rate that yields equilibrium in

the foreign exchange market at time t is affected not only by the basic factors of supply and demand for money, but also by the expected rate of change of the exchange rate which motivates domestic and foreign residents to move assets either into or out of foreign exchange depending on whether the price of foreign exchange is expected to rise or fall.

2.1.2.- The Equilibrium Rational Expectations model.

The interest rate arbitrage condition (2.5) explicitly introduces expectations of the future exchange rate into the monetary model, and alters the estimating equation.

From the PPP assumption (2.4), agents in the economy would anticipate exchange rates to change according to the anticipated differential in the rates of domestic and foreign inflation:

$$\Delta s_t^e = \pi_t - \pi_t^*, \quad (2.8)$$

where π and π^* denote expected domestic and foreign inflation, respectively.

Substitution of (2.8) into (2.7) then gives

$$s_t = z_t + \lambda(\pi_t - \pi_t^*), \quad (2.9)$$

where we have assumed that $n = n^*$ and where $z = (m - m^*) - \phi(y - y^*)$. Equation (2.9) states that, everything else being constant, higher domestic anticipated inflation tends to depreciate the value of domestic currency. The higher anticipated inflation will be associated with higher domestic nominal interest rates, which consequently reduce domestic money demand and require a reduction in the value of domestic currency to sustain asset market equilibrium.

Alternatively, Bilson (1979a) argues that the expected value of the rate of depreciation of the exchange rate may be interpreted as the forward premium in the exchange rate, algebraically:

$$\Delta s_t^e = f_t - s_t, \quad (2.10)$$

where f is the logarithm of the forward exchange rate over the period

equal to the maturity of the assets to which i and i^* correspond.

The necessary assumptions are that the forward rate is determined by profit maximizing speculators who offer, in aggregate, an infinitely elastic supply of forward contracts at a price equal to the expected future spot price, and that the speculators are rational, which implies that their expected rate of depreciation is equal to the rate predicted by the model itself.

Substitution of equation (2.10) into (2.7) yields

$$s_t = z_t * \lambda (f_t - s_t), \quad (2.11)$$

or, solving for s ,

$$s_t = \frac{1}{(1+\lambda)} z_t + \frac{\lambda}{(1+\lambda)} f_t \quad (2.11a)$$

Equations (2.11) and (2.11a) suggest that an expected appreciation reflected in a fall in the forward rate would be reflected in a spot appreciation as well.

Equations (2.11) and (2.11a) assume that the forward rate is exogenous, but it is really simultaneously determined with the spot exchange rate. To solve this problem we can, following Kuhlhagen (1979), estimate (2.11) by two-stage least squares, where the forward premium ($f-s$) is treated as an endogenous explanatory variable with levels and changes of the exogenous variables used as instruments in the first stage of the estimation and the relative money supply variable treated as exogenous if the sample period is one of floating rates. Alternatively, we can introduce the efficient market hypothesis which states that, under conditions of risk neutrality, zero transaction costs, rational use of information, and competitive markets (see Fama, 1970):

$$f_t = E_t s_{t+1}, \quad (2.12)$$

where $E_t s_{t+1}$ is the expected value of the spot rate in period $t+1$, conditional upon the information available in period t . Equation (2.12) states that the forward rate is the conditional expectation of

the future spot exchange rate.

Combining equations (2.12) and (2.11a), we obtain

$$s_t = \frac{1}{(1+\lambda)} z_t + \frac{\lambda}{(1+\lambda)} E_t s_{t+1} \quad (2.13)$$

To complete the determination of the current spot rate, it is necessary to know the current expectations regarding s_{t+1} . Since it is assumed that market participants form their expectations according to the rational expectation hypothesis (REH) (see Muth, 1961), they know (or alternatively, act as if they know) equation (2.13). On taking the rational expectations operator E_t , conditioned on all information available at time t throughout (2.13) gives

$$E_t s_{t+1} = \tilde{\lambda} E_t z_{t+1} + \tilde{\lambda} E_t s_{t+2}, \quad (2.13a)$$

where $\tilde{\lambda} = \frac{1}{(1+\lambda)}$. Substituting (2.13a) into (2.13), we have

$$s_t = \tilde{\lambda} z_t + \hat{\lambda} \tilde{\lambda} E_t z_{t+1} + \hat{\lambda}^2 E_t s_{t+2},$$

where $\hat{\lambda} = \frac{\lambda}{(1+\lambda)}$. Forward substituting yields

$$s_t = \tilde{\lambda} \sum_{j=0}^{\infty} \hat{\lambda}^j E_t z_{t+j}, \quad (2.14)$$

where we have assumed that the convergence condition

$$\lim_{j \rightarrow \infty} \hat{\lambda}^j E_t s_{t+j} = 0$$

holds in order to ensure an economically nonexplosive solution. Since $\hat{\lambda} < 1$, convergence is guaranteed subject to z_t being covariance stationary (see Hansen and Sargent, 1980).

Equation (2.14) states the equilibrium rational expectation model. It shows that, under the rational expectation assumption, the current exchange rate depends on the expected future, as well as the actual current values of the exogenous variables of the model.

Note that in an efficient market, the exchange-rate path is a mirror image of the exogenous-variable path. Therefore, since z is not restricted to follow some specific path, the exchange rate path is not

restricted either. For example, assuming that z follows a first-order autoregressive process, so that

$$z_t = \rho z_{t-1} + u_t, \quad (2.15a)$$

where ρ is a parameter whose value lies between plus and minus one, and u is a serially uncorrelated random variable, then

$$z_{t+1} = \rho^1 z_t + \sum_{j=0}^{1-1} \rho^j u_{t+1-j}.$$

Consequently, $E_t z_{t+i} = \rho^i z_t$, $i=1,2,\dots$, and thus

$$s_t = \tilde{\lambda} z_t \sum_{l=0}^{\infty} \left\{ \frac{\lambda \rho}{(1+\lambda)} \right\}^l = \frac{1}{(1+\lambda(1-\rho))} z_t \quad (2.15b)$$

if the convergence condition $|\lambda \rho / (1+\lambda)| < 1$ holds.

From equations (2.15a) and (2.15b) it follows that the exchange rate is a random walk only if $\rho=1$ (i.e., if the exogenous variables follows a random walk) or if $\lambda=0$ (i.e., if the demand for money is interest inelastic). Therefore, an important implication that follows from equation (2.14) is that the observed volatility of exchange rates can be explained by the instability in the expectations of future levels of the exogenous variables z_t . Depending on the value of λ , the exchange rate will be sensitive to a revision of expectations following an unanticipated shock and will thus make the path of the exchange rate extremely volatile.

In order to express equation (2.14) in terms of observable variables, Hoffman and Schlagenhauf (1983) assume that the exogenous variables follow an integrated first-order autoregressive, that is an ARIMA(1,1,0) process

$$\Delta x_t = \rho_x \Delta x_{t-1} + u_{xt}, \quad |\rho| < 1 \quad (2.16)$$

that can be expressed as

$$x_t = x_{t-1} + \rho_x \Delta x_{t-1} + u_{xt}, \quad (2.17)$$

where $x=m$, m^* , y , or y^* , and u_{xt} is a white noise error term.

It follows from equation (2.16) that

$$\Delta x_{t+1} = \rho_x^1 \Delta x_t + \sum_{h=0}^{1-1} \rho_x^1 u_{x,t+1-h},$$

and hence

$$E_t \Delta x_{t+1} = \rho_x^1 \Delta x_t \quad (2.18)$$

However, from equation (2.17) we have that

$$E_t x_{t+j} = x_t + \sum_{i=1}^j E_t \Delta x_{t+i}. \quad (2.19)$$

Therefore, on substituting (2.19) into (2.18), we obtain

$$E_t x_{t+j} = x_t + \left(\sum_{i=1}^j \rho_x^i \right) \Delta x_t.$$

This j -period forecast may then be used to replace the unobservable expected values in (2.14). This last equation then becomes

$$\begin{aligned} s_t = m_t - m_t^* - \phi(y_t - y_t^*) + \left(\frac{\lambda \rho_m}{1 + \lambda(1 - \rho_m)} \right) \Delta m_t - \left(\frac{\lambda \rho_m^*}{1 + \lambda(1 - \rho_m^*)} \right) \Delta m_t^* \\ - \left(\frac{\phi \lambda \rho_y}{1 + \lambda(1 - \rho_y)} \right) \Delta y_t + \left(\frac{\phi \lambda \rho_y^*}{1 + \lambda(1 - \rho_y^*)} \right) \Delta y_t^*, \end{aligned} \quad (2.20)$$

which is now an equation with all expectations eliminated. Sufficient conditions for the stability of the solution implied by (2.20) are that $\lambda > 0$ and that $|\rho_x| < 1$.

Note that when ρ_x is set equal to zero, we obtain the same random walk process result as in equation (2.15a).

2.2.-THE STICKY-PRICE MONETARY MODEL.

This model, developed by Dornbusch (1976) and Frankel (1979), resembles the flexible-price monetary model in its description of how exchange rates are determined in the long run. But its predictions about short-run behavior are significantly different because of its assumption that prices are sticky in the short run, responding only gradually to excess demand and supply in the goods market. Money-market equilibrium

in the short run is maintained by interest rates. The differential between domestic and foreign interest rates may in the short run deviate from the differential between expected inflation rates.

2.2.1.-The Dornbusch model.

A discrete-time version of the Dornbusch (1976) model is given by the following behavioral equations (see Backus, 1984):

$$(m_t - m_t^*) - (p_t - p_t^*) = \phi(y_t - y_t^*) - \lambda(i_t - i_t^*), \quad (2.21)$$

$$(i_t - i_t^*) = E_t s_{t+1} - s_t, \quad (2.5a)$$

$$E_t(p_{t+1} - p_{t+1}^*) - (p_t - p_t^*) = \delta\{s_t - (p_t - p_t^*)\} + \gamma(y_t - y_t^*) - \sigma(i_t - i_t^*) \quad (2.22)$$

The equation (2.21) is derived from equations (2.1) and (2.2) assuming that $n=n^*$. It represents the money-market equilibrium condition. Equation (2.5a) is the uncovered-interest-parity condition under the assumption of rational expectations⁸. Equation (2.22) represents a price adjustment process. These three equations in addition to the assumption of rational expectations determine four endogenous variables: $(i_t - i_t^*)$, $E_t(p_{t+1} - p_{t+1}^*)$, s_t and $E_t s_{t+1}$.

From equation (2.21), we have

$$(i_t - i_t^*) = \frac{1}{\lambda} \{ \phi(y_t - y_t^*) - (m_t - m_t^*) + (p_t - p_t^*) \}. \quad (2.21a)$$

Substituting (2.21a) into (2.5a) and (2.22) yields

$$E_t s_{t+1} - s_t = \frac{1}{\lambda} \{ \phi(y_t - y_t^*) - (m_t - m_t^*) + (p_t - p_t^*) \}, \quad (2.5b)$$

and

$$\begin{aligned} E_t(p_{t+1} - p_{t+1}^*) - (p_t - p_t^*) &= \delta\{s_t - (p_t - p_t^*)\} + \gamma(y_t - y_t^*) \\ &\quad - \sigma/\lambda \{ \phi(y_t - y_t^*) - (m_t - m_t^*) + (p_t - p_t^*) \}, \end{aligned} \quad (2.22a)$$

⁸ Equation (2.5a) is derived by combining equations (2.5), (2.10) and (2.12).

or, solving (2.5b) and (2.22a) for $E_t s_{t+1}$ and $E_t(p_{t+1} - p_{t+1}^*)$, respectively, we obtain

$$E_t s_{t+1} = s_t + \frac{1}{\lambda}(p_t - p_t^*) + \frac{\phi}{\lambda}(y_t - y_t^*) - \frac{1}{\lambda}(m_t - m_t^*), \quad (2.23)$$

and

$$\begin{aligned} E_t(p_{t+1} - p_{t+1}^*) &= \delta s_t + (1 - \delta - \sigma/\lambda)(p_t - p_t^*) \\ &+ (\gamma - \phi\sigma/\lambda)(y_t - y_t^*) + \sigma/\lambda(m_t - m_t^*). \end{aligned} \quad (2.24)$$

In matrix form,

$$\begin{pmatrix} E_t s_{t+1} \\ E_t(p_{t+1} - p_{t+1}^*) \end{pmatrix} = A \begin{pmatrix} s_t \\ p_t - p_t^* \end{pmatrix} + B \begin{pmatrix} y_t - y_t^* \\ m_t - m_t^* \end{pmatrix} \quad (2.25)$$

$$\text{where } A = \begin{pmatrix} 1 & 1/\lambda \\ \delta & (1 - \delta - \sigma/\lambda) \end{pmatrix} \text{ and } B = \begin{pmatrix} \phi/\lambda & -1/\lambda \\ (\gamma - \phi\sigma/\lambda) & \sigma/\lambda \end{pmatrix}.$$

If the forcing variables, $(y - y^*)$ and $(m - m^*)$, are not expected to change from their present values [i. e., $E_t(m_{t+j} - m_{t+j}^*) \equiv m_t - m_t^*$ and $E_t(y_{t+j} - y_{t+j}^*) \equiv y_t - y_t^*$], the system has a long-run equilibrium, which it approaches asymptotically. In particular

$$E_t s_{t+1} - s_t = \theta(\tilde{s} - s)_t, \quad (2.26)$$

where \tilde{s} is the expected long-run value of the exchange rate and θ is one minus the stable root of the dynamic system (2.25).

Equation (2.26) states that the expected value of the change in the exchange rate is a function of the gap between the long-run rate and the current spot rate.

Combining (2.21) and (2.5b), we obtain

$$s_t = \tilde{s}^{-1/\lambda\theta} (p_t - p_t^*)^{-\phi/\lambda\theta} (y_t - y_t^*)^{1/\lambda\theta} (m_t - m_t^*). \quad (2.27)$$

By setting $E_t s_{t+1} = s_t = \tilde{s}$ and $E_t (p_{t+1} - p_{t+1}^*) = (p_t - p_t^*) = (\tilde{p} - \tilde{p}^*)$ in (2.23) and (2.24), we have

$$\tilde{s} = \tilde{s}^{1/\lambda} (\tilde{p} - \tilde{p}^*)^{\phi/\lambda} (y_t - y_t^*)^{-1/\lambda} (m_t - m_t^*), \quad (2.23a)$$

and

$$\begin{aligned} (\tilde{p} - \tilde{p}^*) &= \delta \tilde{s} + (1 - \delta - \sigma/\lambda) (\tilde{p} - \tilde{p}^*) \\ &\quad + (\gamma - \phi\sigma/\lambda) (y_t - y_t^*) + \sigma/\lambda (m_t - m_t^*). \end{aligned} \quad (2.24a)$$

Solving (2.23a) for $(\tilde{p} - \tilde{p}^*)$ gives

$$(\tilde{p} - \tilde{p}^*) = (m_t - m_t^*) - \phi (y_t - y_t^*), \quad (2.23b)$$

and substituting (2.23b) into (2.24a) yields

$$\delta \tilde{s} = (\delta + \sigma/\lambda) \{ (m_t - m_t^*) - \phi (y_t - y_t^*) \} - (\gamma - \phi\sigma/\lambda) (y_t - y_t^*) - \sigma/\lambda (m_t - m_t^*).$$

Therefore,

$$\tilde{s} = (m_t - m_t^*) - (\phi + \gamma/\delta) (y_t - y_t^*). \quad (2.28)$$

Substituting (2.28) into (2.27), we get

$$s_t = (1 + 1/\lambda\theta) (m_t - m_t^*)^{-1/\lambda\theta} (p_t - p_t^*) - (\phi + \gamma/\delta + \phi/\lambda\theta) (y_t - y_t^*). \quad (2.29)$$

From equation (2.29), we note that the coefficient of $(m - m^*)$ exceeds one (i.e., there is a short-run overshooting) and the coefficient of $(m - m^*)$ and $(p - p^*)$ sum to one (i.e., the long-run neutrality of money property of the flexible-price monetary model holds in this sticky-price model).

With the new set of assumptions, an increase in the domestic money supply will, in the long run, have consequences similar to those predicted in the flexible-price monetary model: domestic prices will be

proportionately higher, because this is the only way the demand for money can expand to match the new supply, and the expected rate must be proportionately depreciated (i.e., the SPMM has the long-run property of monetary neutrality as has the FPMM). The short-run implications, however, are significantly different. With prices sticky in the short run, a monetary expansion causes the real money supply to increase, so that the domestic nominal interest rate must fall to restore money market equilibrium. For the uncovered-interest-rate parity to hold, a fall in the domestic interest rate, given the foreign interest rate, requires an overshooting of the new (higher) long-run equilibrium exchange rate such that the subsequent expected appreciation just matches the nominal interest rate differential. An incipient capital inflow develops that depreciates the exchange rate by the required amount⁹.

2.2.2.- The Frankel model.

Frankel (1979, 1981) extends the model to the case of secular inflation. This variant of the SPMM is known as the real interest rate differential model. The price equation (2.22) is amended by allowing a steady rate of inflation, ($\tilde{\pi}$ and $\tilde{\pi}^*$) The system of behavioral equations can be now expressed as follows (see Backus, 1984):

⁹ Frenkel and Rodriguez (1982) note that, in addition to the discrepancy of adjustment speeds in goods and asset markets (asset markets adjust instantaneously whereas goods markets adjust only slowly over time), other explanations of the exchange rate overshooting phenomenon include imperfect international capital mobility, insufficient speculation in the markets for foreign exchange, effects of new information on commodity and asset markets, and peculiarities of the portfolio adjustment process. Karacaoglu and Ursprung (1988) show that the speed of adjustment of the aggregate portfolio should also be included as an additional factor.

$$(m_t - m_t^*) - (p_t - p_t^*) = \phi(y_t - y_t^*) - \lambda(i_t - i_t^*), \quad (2.21)$$

$$(i_t - i_t^*) = E_t s_{t+1} - s_t, \quad (2.5b)$$

$$E_t(p_{t+1} - p_{t+1}^*) - (p_t - p_t^*) = \delta(s_t - (p_t - p_t^*)) + \gamma(y_t - y_t^*) - \sigma(i_t - i_t^*) + (\tilde{\pi} - \tilde{\pi}^*). \quad (2.30)$$

If we assume that the current income levels and the current rates of expected long-run inflation are not expected to change in the future, the rational expectations equation (2.26) becomes

$$E_t s_{t+1} - s_t = \theta(\tilde{s} - s_t) + (\tilde{\pi} - \tilde{\pi}^*), \quad (2.26a)$$

i. e., it is assumed that the exchange rate is expected, in the short run, to move towards its long-run equilibrium value, and, in the long run, to change at the rate of the expected long-run inflation differential. Substituting $E_t s_{t+1} - s_t$ in (2.26a) from (2.5a) and solving for s_t , we obtain

$$s_t = \tilde{s} - \frac{1}{\theta} \{ (i_t - \tilde{\pi}) - (i_t^* - \tilde{\pi}^*) \}. \quad (2.31)$$

This equation states that the spot exchange rate moves directly with changes in the underlying equilibrium rate and with changes in the real interest differential, where the domestic real interest rate is defined as $i - \tilde{\pi}$.

As before, solving (2.21) for $(i - i^*)$, we get (2.21a). Substituting (2.21a) into (2.5a) and (2.30) yields to

$$E_t s_{t+1} - s_t = \frac{1}{\lambda} \{ \phi(y_t - y_t^*) - (m_t - m_t^*) + (p_t - p_t^*) \}, \quad (2.5b)$$

$$E_t(p_{t+1} - p_{t+1}^*) - (p_t - p_t^*) = \delta(s_t - (p_t - p_t^*)) + \gamma(y_t - y_t^*) - \sigma / \lambda \{ \phi(y_t - y_t^*) - (m_t - m_t^*) + (p_t - p_t^*) \} + (\tilde{\pi} - \tilde{\pi}^*). \quad (2.30a)$$

In the steady state $E_t \tilde{s}_{t+1} - \tilde{s}_t = E_t(\tilde{p}_{t+1} - \tilde{p}_{t+1}^*) - (\tilde{p}_t - \tilde{p}_t^*) = (\tilde{\pi} - \tilde{\pi}^*)$, so in the steady state, equations (2.5b) and (2.30a) become

$$\tilde{\pi}-\pi^* = 1/\lambda \{ \phi(\tilde{y}-y^*) - (\tilde{m}-m^*) + (\tilde{p}-p^*) \}, \quad (2.5c)$$

and

$$\begin{aligned} \tilde{\pi}-\pi^* = & \delta \{ \tilde{s} - (\tilde{p}-p^*) \} + \gamma(\tilde{y}-y^*) - \sigma/\lambda \{ \phi(\tilde{y}-y^*) \\ & - (\tilde{m}-m^*) + (\tilde{p}-p^*) \} + \tilde{\pi}-\pi^*. \end{aligned} \quad (2.30b)$$

Solving (2.5c) for $(\tilde{p}-p^*)$, we obtain

$$(\tilde{p}-p^*) = \lambda(\tilde{\pi}-\pi^*) - \phi(\tilde{y}-y^*) + (\tilde{m}-m^*). \quad (2.32)$$

Substituting (2.32) into (2.30b) and rearranging, we have

$$\tilde{s} = (\tilde{m}-m^*) - (\phi + \gamma/\delta)(\tilde{y}-y^*) + (\lambda + \sigma/\delta)(\tilde{\pi}-\pi^*). \quad (2.33)$$

Finally, the short-run exchange rate relation is obtained by substituting (2.33) into (2.31), and assuming that the equilibrium money supplies and income levels and the expected rate of inflation are given by their current actual levels,

$$\begin{aligned} s_t = & (m_t - m_t^*) - (\phi + \gamma/\delta)(y_t - y_t^*) - 1/\theta(i_t - i_t^*) \\ & + (\lambda + \sigma/\delta + 1/\theta)(\pi_t - \pi_t^*). \end{aligned} \quad (2.34)$$

Note that, from equation (2.34), the model does not predict short-run overshooting. Frankel's own version is somewhat simpler, because income and the interest differential do not affect price changes (i.e., $\gamma = \sigma = 0$), but neither restriction changes the model's reduced-form predictions.

Comparing equation (2.34) to the reduced-form equation for the flexible-price monetary model (2.6), we see that it only differs in the sign of the interest rate coefficient and in the presence of the steady-state inflation differential.

An obvious problem with equation (2.34) is the questionable exogeneity of $(i - i^*)$. Driskill and Sheffrin (1981) use equation (2.21a) to eliminate this problem, obtaining

$$s_t = (1 + \frac{1}{\lambda\theta})(m_t - m_t^*) - (\phi + \frac{\gamma}{\delta} + \frac{\phi}{\lambda\theta})(y_t - y_t^*) - (\frac{1}{\lambda\theta})(p_t - p_t^*) \\ + (\lambda + \frac{\sigma}{\delta} + \frac{1}{\theta})(\pi_t - \pi_t^*). \quad (2.34a)$$

From equation (2.34a) we note that the model now predicts short-run overshooting and long-run neutrality.

Comparing equations (2.29) and (2.34a), we can say that if the expected inflation rates in the two countries are equal and constant, Frankel's model becomes the same as the Dornbusch model. Therefore, the latter can be viewed, as suggested by Frankel (1979), as a special case of the former.

3.- THE PORTFOLIO-BALANCE MODEL.

Unlike the monetary models, the portfolio-balance model does not assume that domestic and foreign interest-bearing assets are perfect substitutes¹⁰. The exchange rate in this model is assumed to adjust the value of financial assets in private portfolios to the level considered optimal by wealth-holders, given interest rates and asset stocks.

Business cycles do not generally happen uniformly across countries, so when one country is experiencing rapid growth, another may be in a recession. Investors, who attempt to maximize their expected portfolio returns consistent with individually acceptable levels of portfolio risk, can attain substantial advantages in risk reduction through portfolio diversification in foreign assets, by eliminating part of the cyclical fluctuations in their portfolios that could arise from domestic business cycles. Therefore, some of what could be considered the systematic or market-related risk (i. e., the risk present in all investment opportunities) in terms of strictly domestic investment opportunities becomes a nonsystematic risk (i. e., the risk that is unique to a particular security and that can be countered by mixing that security with other securities in a diversified portfolio) when investors broaden their opportunities to include foreign as well as domestic investments. Increasing diversification gradually tends to eliminate the unsystematic risk, leaving only systematic risk. Thus not only do investors tend to diversify their portfolio holdings across industries, but they also realize additional gains by diversifying across countries and/or both countries and industries (see Solnik, 1974; Black, 1978; and Grauer and Hakkansson, 1987).

In one of the early models, described by Branson (1976, 1977), Branson, Halttunen, and Masson (1977), and Branson and Halttunen (1979),

¹⁰ Among the reasons for imperfect substitutability we can point exchange rate risk, differential political and default risks, imperfect information about foreign assets, and government regulation of international capital flows.

domestic residents are assumed to allocate their financial wealth (W) among three assets: domestic money (M), domestically-issued assets (B) with interest rate i , and foreign-issued assets (A), which earn an interest rate i^* . It is assumed that domestic money and bonds are held only by domestic residents. By assuming that foreigners hold only the foreign asset, there will be no valuation effects on foreign wealth from changes in the exchange rate, so Branson and Branson *et. al.* can ignore foreign demand for foreign assets. In this model, price levels at home and abroad play no direct role in the short run. The goods market adjusts to price changes, creating current account imbalances offset by capital flows. These capital flows represent changes in foreign assets, so A is both the net foreign asset position and the stock of foreign-denominated claims.

Assuming static expectations, at each point of time, the asset-market equilibrium conditions are given by:

$$M_t = \mu(i_t, i_t^*) W_t, \quad (3.1)$$

$$B_t = \beta(i_t, i_t^*) W_t, \quad (3.2)$$

$$S_t A_t = \alpha(i_t, i_t^*) W_t, \quad (3.3)$$

$$W_t \equiv M_t + B_t + S_t A_t. \quad (3.4)$$

Equations (3.1) to (3.3) represent the equilibrium condition in the money market, in the home-asset market, and in the foreign-asset market, respectively. Equation (3.4) represents the balance sheet constraint. The desired fraction of wealth held as money is μ , held as domestic bonds, β , and held as foreign assets denominated in domestic currency, α .

If the asset stocks (M , B , and A) are taken as given at any time, the model has three variables, the two interest rates and the exchange rate, but because of the total wealth identity (3.4), only two independent equations. It is assumed that the economy that is described is small (i.e., it takes the interest rate on world-traded assets as

exogenously determined); this allows us to eliminate one variable and to¹¹ render the system mathematically determined .

The pairs of domestic interest and exchange rates (i , S) satisfying the market clearing conditions (3.1) to (3.3) are plotted in Figure 3.1 to give a money market equilibrium curve (MM), a domestic bond market equilibrium curve (BB), and a domestically held foreign asset equilibrium curve (AA).

The MM curve is upward sloping because a rise in the domestic interest rate reduces demand for money, requiring a rise in the exchange rate (depreciation), which increases SA , the stock of foreign assets denominated in domestic currency. This in turn increases wealth, to maintain demand for money equal to the fixed supply. The BB curve is downward sloping because a rise in i increases demand for domestic bonds, requiring a decrease in S (appreciation) to maintain equilibrium in the domestic bond market. The AA curve is also downward sloping since as i rises, the demand for foreign assets falls, and S falls (appreciates) as asset-holders attempt to sell A . The AA curve is flatter than the BB curve because domestic demand for domestic bonds is assumed more responsive than the demand for foreign assets to changes in the domestic interest rate.

The predicted effects of changes in various asset stocks on the exchange rate are as follows:

□ Increase in M : An increase in the domestic monetary base would increase domestic wealth and raise the proportion of wealth held in this asset. At the original interest rate and exchange rate, portfolios would no longer be in their desired proportions, since wealth-holders would

¹¹ Bisignano and Hoover (1980) criticize the use of the small-country assumption in this model without testing if it is appropriate for the particular currency under study. They suggest using the test of Granger-causality on the interest rate on world-traded assets for establishing the small-country assumption.

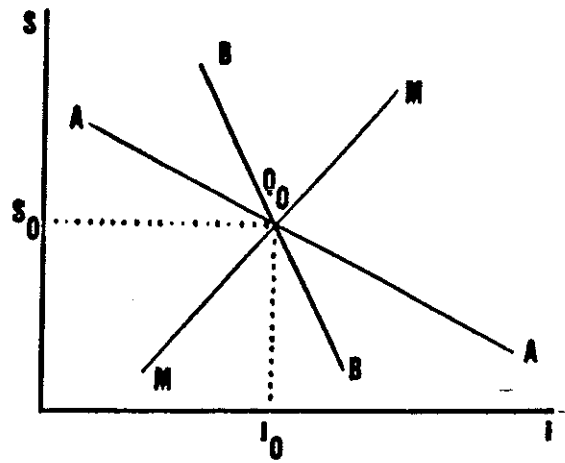


Figure 3.1. PBM: Equilibrium i and S .

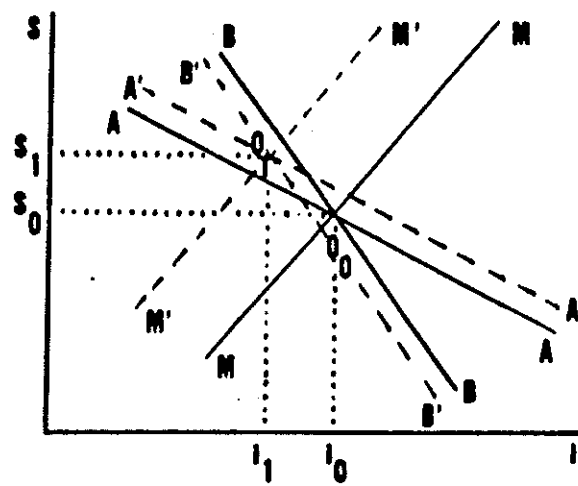


Figure 3.2. PBM: Increase in money, M .

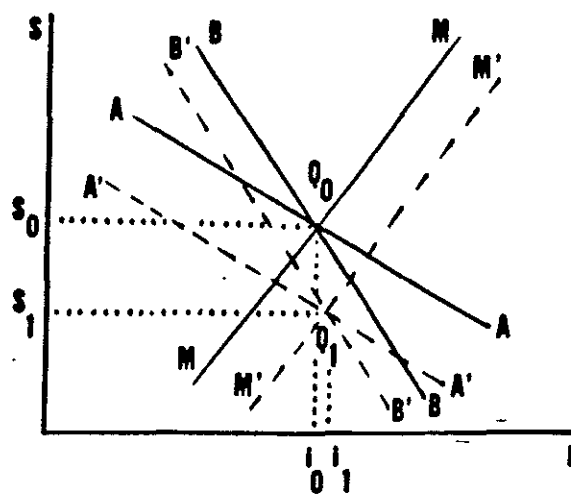


Figure 3.3. PBM: Increase in foreign assets, A.

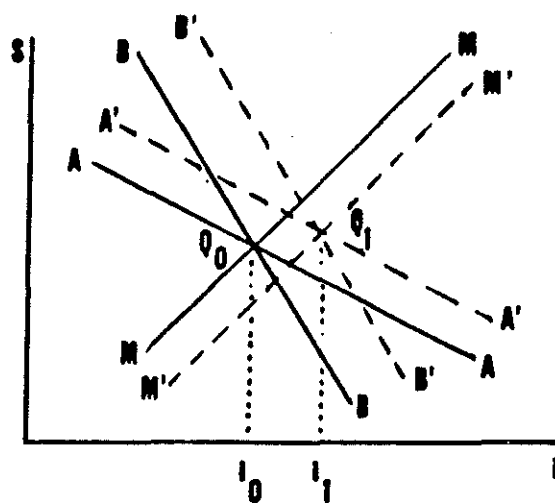


Figure 3.4. PBM: Increase in domestic assets, B.

want to redistribute their wealth increase towards domestic bonds and foreign bonds. With the foreign interest rate fixed, actions of domestic investors to realign their portfolios would result in a drop in the domestic interest rate and a depreciation of the exchange rate. These effects are illustrated in Figure 3.2.

□ Increase in A: The effect of an increase in domestic holdings of foreign assets is illustrated in Figure 3.3. An increase in A does not change the stock of domestic bonds or money, so the domestic interest rate remains unchanged. At a fixed exchange rate, the increase in A would increase SA, the stock of foreign assets denominated in domestic currency. This in turn would increase wealth, and thereby increase the demand for domestic bonds and money beyond the fixed stock of each. Hence, wealth must not increase if the demand and supply of domestic bonds and money are to be equal. Therefore, SA must fall to its former level. Since A is fixed at its new level, only S can fall. It will fall in the exact proportion that A increased; therefore, an increase in the stock of foreign assets denominated in foreign currency appreciates the exchange rate by the same proportion (i. e., The elasticity of S with respect to A is -1).

□ Increase in B: The effects of an increase in B are illustrated in Figure 3.4. Unlike the first two cases, an increase in domestic government bonds has an uncertain effect on the exchange rate. On the one hand, the increase in wealth would increase domestic demand for foreign assets resulting in an exchange rate depreciation. On the other hand, the increase in domestic government debt would raise the domestic interest rate, making foreign bonds less attractive. If the wealth effect were larger than the substitution effect, the net result would be a depreciation of the exchange rate. Branson (1976) has shown that this occurs if domestic bonds and money are better wealth substitutes than domestic bonds and foreign bonds.

If domestic and foreign bonds are better substitutes than domestic bonds and money, the rise in the interest rate that restores the equality between money demand and supply will produce a greater drop in the demand for foreign assets than in the demand for money at the new

level of wealth. The value of the unchanged stock of foreign assets denominated in domestic currency, SA , would then be greater than the demand for them. Thus, with A constant, S must fall (i.e., the exchange rate must appreciate) to bring the value of the supply of foreign assets into line with demand.

On the other hand, if domestic bonds and money are better substitutes than domestic bonds and foreign bonds, the rise in the interest rate which makes money demand equal to money supply produces a smaller drop in the demand for foreign assets. That demand at the new level of wealth exceeds the value of the unchanged stock of foreign assets denominated in domestic currency. SA and A must increase (i.e., the exchange rate must depreciate) to adjust the supply of foreign assets to demand.

The system of equations (3.1) to (3.3) can be solved to yield the following reduced form for the exchange rate:

$$S_t = \varphi_1 + \varphi_2 M_t \pm \varphi_3 B_t - \varphi_4 A_t - \varphi_5 i_t^*, \quad (3.5)$$

where " \pm " denotes that the coefficient of B can be positive or negative.

Substituting the corresponding stocks of the foreign country for i^* , the following bilateral expression is obtained

$$S_t = \varphi'_1 + \varphi'_2 M_t \pm \varphi'_3 B_t - \varphi'_4 A_t - \varphi'_5 M_t^* \pm \varphi'_6 B_t^* - \varphi'_7 A_t^*. \quad (3.5a)$$

In Branson *et al.*'s model, even with fully-adjusted prices, purchasing-power parity need not hold. Interest rates can be changed by changes in domestic (or foreign) asset supplies and this moves the exchange rate away from PPP for prolonged periods.

Frankel (1983) presents a much simpler portfolio-balance model. Assuming again that the domestic residents are the only ones who wish to hold domestically denominated assets, we can identify a capital inflow or outflow with an increase or decrease in the supply of foreign assets in the domestic assets market. If we also assume that investors, in order to diversify exchange risk, balance their portfolios between

domestic and foreign assets in a proportion that depends on the expected rate of return (or risk premium) we can write

$$B/SA = \exp\{k + l(i - i^* - \Delta S^e)\}, \quad (3.6)$$

where we have assumed that the ratio between the stock of domestic-currency denominated bonds (B) to the stock of foreign-currency denominated bonds (which is equal to the accumulation of past current account surpluses under the small-country assumption) expressed in domestic currency (SA) is an exponential function of the risk premium, and where ΔS^e is the expected rate of depreciation.

Assuming static expectations (i.e. $\Delta S^e = 0$), taking logarithm and solving for the exchange rate, we obtain the following equation

$$s_t = -k - l(i_t - i_t^*) + b_t - a_t, \quad (3.7)$$

where, as before, lower-case variables are the logarithm of the upper-case variables, except for i and i^* . Equation (3.7) states that the exchange rate is determined by relative bond supplies and the interest rate differential.

From equation (3.7), a current account deficit, which implies a capital inflow and therefore an increase in the stock of foreign assets, will lead to an appreciation of the domestic currency.

We can use Dooley and Isard's (1983) portfolio-balance framework to extend the analysis allowing domestic and foreign residents to hold both domestic and foreign bonds, while only domestic (foreign) residents can hold domestic (foreign) money. In this case the asset-market equilibrium conditions are given by:

$$M_H = \mu_H(i, i^* - \Delta S^e, Y)W, \quad (3.8)$$

$$B_H = \beta_H(i, i^* + \Delta S^e, Y)W, \quad (3.9)$$

$$SA_H = S\alpha_H(i, i^* + \Delta S^e, Y)W, \quad (3.10)$$

$$M_F^* = \mu_F(i^*, i - \Delta S^e, Y^*)W^*, \quad (3.11)$$

$$B_F = (1/S)\beta_F(i^*, i - \Delta S^e, Y^*)W^*, \quad (3.12)$$

$$A_F = \alpha_F(i^*, i - \Delta S^e, Y^*)W^*, \quad (3.13)$$

$$W = M_H + B_H + SA_H, \quad (3.14)$$

$$W^* = M_F^* + (B/S) + A_F, \quad (3.15)$$

where M , B , W , A , μ , β , α and i are defined as before, where Y (Y^*) is an index of transaction demand, and where the subscripts "H" and "F" denote net holding of private residents in the home country and the foreign country, respectively.

Equations (3.8) to (3.13) state that the proportion of their wealth which domestic and foreign residents wish to hold in each asset now depends on their relative expected common-currency yields, and hence on the interest rates on domestic and foreign bonds and the expected movements of the exchange rate. Equations (3.14) and (3.15) represent the balance sheet constraint for the home and the foreign country, respectively.

The market clearing condition for each asset is given by:

$$M_H = M, \quad (3.16)$$

$$B_H + B_F = B, \quad (3.17)$$

$$A_H + A_F = A, \quad (3.18)$$

$$M_F = M^*. \quad (3.19)$$

Substituting the behavioral assumptions (3.8) to (3.13) into equations (3.16) to (3.19), we can solve for the variables that clear asset markets

$$\mu_H(i, i^* + \Delta S^e, Y)W = M, \quad (3.20)$$

$$\beta_H(i, i^* + \Delta S^e, Y)W + (1/S)\beta_F(i^*, i - \Delta S^e, Y^*)W^* = B, \quad (3.21)$$

$$S\alpha_H(i, i^* + \Delta S^e, Y)W + \alpha_F(i^*, i - \Delta S^e, Y^*)W^* = A, \quad (3.22)$$

$$\mu_F(i^*, i - \Delta S^e, Y^*)W^* = M^*. \quad (3.23)$$

Consider the case in which asset stocks (M , B , M^* and A) are predetermined and interest rates (i , i^*) and exchange rates (S , ΔS^e) are variables. By constraints (3.14) and (3.15), only three of the four market clearing conditions (3.20) to (3.23) are independent. If we assume again that the home country is small and i^* is also predetermined, the system can be solved for S , ΔS^e and i . The reduced-form equation for the exchange rate is now as follows

$$S_t = \theta_1 + \theta_2 M_t + \theta_3 B_t - \theta_4 A_t - \theta_5 M_t^* + \theta_6 B_t^* + \theta_7 A_t^* - \theta_8 Y_t + \theta_9 Y_t^*. \quad (3.24)$$

4.- MONETARY MODELS: EMPIRICAL EVIDENCE AND EXTENSIONS

4.1.- REDUCED-FORM ECONOMETRIC EVIDENCE¹².

The *Frenkel-Mussa-Bilson model* has been applied by a number of researchers both for the inter-war period of flexible exchange rates and for the recent floating exchange experience. Table 4.1 summarizes some representative results for the 1970s and 1980s experiment with floating exchange rates¹³. Although the model delivered apparently favorable results for the 1970's, from around 1979 the empirical studies have been less favorable to this model, finding that few coefficients are correctly signed and statistically significant, detecting autocorrelation problems, and poor explanatory power.

In Table 4.2 we report some empirical tests of the sticky-price monetary model for the recent period of floating rates.

The *Dornbusch (1976) model* is estimated by Backus (1984) for the CD/US\$ rate for the 1971.I-1980.IV period and by Leventakis (1987) for the DM/US\$ rate for the period 1974.I-1980.IV. Neither of these tests offers support for the model or evidence of the overshooting postulated by the model.

Frankel's (1979) model is found to produce very supportive results in Frankel's original study using monthly data of the US\$/DM rate for the period 1974.07-1978.02. However, the model gave signs of break-down

¹² See the appendix for a list of abbreviations used in this paper.

¹³ Frenkel (1976), in his study of the DM/US\$ rate for the hyperinflation period 1920.02-1923.11, concludes that "the empirical results are consistent with the monetary (or asset) approach to exchange rates". Similar conclusions are reached by Clements and Frenkel (1980) and by Frenkel and Clements (1981), studying, respectively, the US\$/UKP rate for the period 1921.02-1925.05 and the FF/US\$ and FF/UKP rates for the period 1921.01-1924.03. However, estimates of equation (2.6) for other currencies in the interwar period have not been so successful (see MacDonald, 1983).

Table 4.1: Tests of the FPM for the 1970s and 1980s.

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Bilson (1978a)	DM/UKP 1972.01-1976.04	s	$m, m^*, y, y^*, f-s$ s_{t-1}	CORC	$(1-i^*)$ represented by the forward premium, f-s. Inclusion of lagged dependent variable and AR(1) error term.	"strong empirical support"
Bilson (1978b)	DM/UKP 1970.04-1977.05	s	$m, m^*, y, y^*, f-s$ s_{t-1}, t	CORC	$(1-i^*)$ represented by f-s. Lagged dependent variable and trend.	"consistent with the monetary theory"
Hodrick (1978)	US\$/UKP 1972.07-1975.04	s	$(m-m^*), \ln(1+i)$ $\ln(1+i^*), (y-y^*)$ $[\ln(1+j^*) - \ln(1+i^*)]$	OLS	Inclusion of the differential between the 3-months Europound interest rate (j) and the 3-months UK Treasury bill interest rate.	"broadly consistent with the predictions of the theory"
	US\$/UKP 1973.04-1975.09	s	$(m-m^*), \ln(1+i)$ $\ln(1+i^*), (y-y^*)$	OLS	Allows for different coefficients for m and m^* and for y and y^* .	
Bilson (1979a)	DM/US\$ 1983.I-1978.III	s	$(m-m^*), (y-y^*),$ $(f-s), t, t^2$	OLS	$(1-l^*)$ represented by f-s. polynomial lags on the explanatory variables, inclusion of trend and AR(1) error.	"provide strong support for the monetary theory".

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Kohlhagen (1979)	DM/FF FF/US\$ DM/US\$ 1973.03-1975.05	s	$(m-m^*), (y-y^*), f-s$	2SLS	Levels and changes of the exogenous variables used as instruments in the first stage of estimation.	"for each of the markets most of the important coefficients had the correct sign and are significant".
		s	$(m-m^*), (y-y^*), f-s$ $(p-p)$	2SLS	Inclusion of relative prices as an explanatory variable. (partial adjustment to PPP)	in general, the revised estimation is somewhat better although some coefficients are significantly different for what was expected.
Keran (1979)	CD/US\$ IL/US\$ SF/US\$ 1974.01-1977.12 FF/US\$ DM/US\$ JY/US\$ UKP/US\$ 1975.01-1977.12	s	$\sum \ln(EM/EM)_{T-t}$	OLS	Use of the ratio of excess money in the USA to the excess money in each other country. OLS estimation with third-degree polynomial distributed lags.	Mixed results.
Putman and Woodbury (1979)	UKP/US\$ 1972.01-1977.12 1972.I-1977.IV	s	$m, m^*, y, y^*, \ln i, \ln i^*$	HL	Adjustment for the presence of autocorrelation	"support for the monetary approach"
Resuio and Wildford (1980)	US\$/UKP 1973.I-1981.IV US\$/IL 1973.I-1976.II	s	$(m-m^*), (y-y^*), (\ln i - \ln i^*)$ or $(m-m^*), (\theta y - \theta^* y^*), (\ln i - \ln i^*)$	OLS	Consideration of the possible bias due to the assumption of equal income elasticities for both countries.	"The results tend to support the general monetary approach". "Consideration of the possible bias...improves the statistical results".

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Bisignano and Hoover (1980)	US\$/DM US\$/JY US\$/IL US\$/CD 1973.03-1978.12	s	$(m-m^*), (y-y^*), (i-i^*)$ or $(m-m^*), (\phi y - \frac{\phi}{L} y^*), (ln i - ln i^*)$	OLS CORC FAIR	Also addition for a relative bond-money variable $(x-x^*)$ as a proxy for real rate differential ("real rate monetary approach") and lagged exchange rate.	"the overall impression one obtains for the basic monetary approach and the real monetary approach is that it can in some cases do a very reasonable job explaining exchange rate movements".
Dorbusch (1980)	DM/US\$ 1973.II-1974.IV 1973.II-1978.I	s or $s-m+m^*$	$(m-m^*), (y-y^*), (i-i^*)$ $(1-L^{-1}L)$ $(m-m^*), (\phi y - \frac{\phi}{L} y^*), (ln i - ln i^*)$	OLS OLS	inclusion of long-term interest differential constraining coefficients of relative moneys to unity, and inclusion of lagged dependent variable.	"little support for the monetary approach"
Hacche and Townsend (1981)	UKP/US\$ 1972.02-1977.10	s	m, m^*, y, y^*, i, i^*	CORC	correction for autocorrelation.	"the domestic money stock remains significant and the interest rate parameters apparently confirm the monetary ...model".
Franke! (1982b)	DM/US\$ 1974.I-1980.IV 1974.01-1980.II	s	m, m^*, y, y^*, w, w^* $(f-s)$	OLS	inclusion of wealth, in addition to income, as a transactions variables in the money demand function	"the monetary model will wealth included succeeds in explaining the mark/dollar exchange rate during a period where the monetary approach without wealth and the portfolio balance approach both fail".

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Hoffman and Schlagenhauf (1983)	US\$/DM US\$/FF US\$/UKP 1974.06-1979.12	s	$m, m^*, y, y^*, \Delta m, \Delta m^*, \Delta y, \Delta y^*$	FIML	equilibrium rational expectations model assuming that the exogenous variables follow AIRMA(1,1,0) processes.	the "results are most supportive of the model".
Dolado and Durán (1983)	PTA/US\$ 1974.01-1982.10	Δs	$\Delta s_{t-1}^*, \Delta(m-m^*), \Delta(i-\pi^*), (s-p-p^*), m_{t-1}^*, \pi_{t-1}^*, y_{t-1}^*$	2SLS	Inclusion of risk and dummy variables for depreciations and seasonal adjustment. Also estimation with a reaction function for the monetary authorities.	"...it seems that the monetary model's explanatory variables tend to affect strongly the explanation of the short-term exchange rate fluctuations.
Backus (1984)	CD/US\$ 1971.I-1980.IV	s	$(m-m^*), (y-y^*), (i-i^*)$	OLS	also allows for domestic and foreign variables to have different coefficients and inclusion of s_{t-1} as an explanatory variable	poor support to the monetary model.
		s	$(m-m^*), (y-y^*)_{t-1}$	OLS	equilibrium rational expectations model assuming that the explanatory variables follow AR(1) and AR(2) processes.	little gain with respect to the previous model

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Harneck (1984)	9 currencies 1973.I-1979.IV	s	$(m-m^*), (y-y^*)(1-i^*)$	OLS CORC	also allows for lagged adjustments in real balances by introducing s_{t-1} as an explanatory variable. Also $(\pi-\pi^*)$ replaces $(i-i^*)$.	"the estimates of the flexible-price monetary model...generally do not provide support to the model".
Laffrance and Racette (1985)	CD/US\$ 1971.I-1980.IV	s	$(m-m^*), (y-y^*)(1-i^*)$	OLS CORC		"the monetary approach is not acceptable".
		s	$(m-m^*), (y-y^*)(1-i^*)$ $(w-w^*)$	OLS CORC	inclusion of wealth effect in the demand for money.	although the equation looks much better than the previous one, the monetary model is still not acceptable.
Gómez-Amán (1985)	PTA Effective Rate 1973.III-1981.III	EER ^d	$(m-m^*), (y-y^*)(1-i^*)$ $(w-w^*), RES$	CORC	estimation with a reaction function for the monetary authorities. Inclusion of reserves as an explanatory variable.	"...the absence of statistical significance for any of the coefficients in the relative demand for money does not allow us to fully the validity such model".
Woo (1985)	DM/US\$ 1974.03-1981.10	s	$(m-m^*), (m-m^*)_{t-1}, y, y^*$ s_{t-1}	FIML	VAR model of the exogenous variables.	"It appears that the monetary model is still alive".
Aguado (1986)	PTA/US\$ 1977.08-1980.04	s	$(m-m^*), (y-y^*)(1-i^*)$	OLS OLS	$(i-i^*)$ measured as $(f-s)$ also allows domestic and foreign variables to have different coefficients	"good fit (...). However, the values for the coefficients are inconclusive".

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^d	Estimation Technique ^b	Special Features	Results
Gómez-Amián and Navarro Gómez (1986)	PTA Effective Rate 1973.07-1981.09	s	$m, \Delta m, \Delta^2 m, \Delta^2 m_{t-1},$ $m^*, \Delta m^*, \Delta^2 m^*,$ $\Delta^2 m^*_{t-1}, y_t, \Delta y,$ $\Delta y_{t-1}, y, \Delta y, \Delta y_{t-1}$	3SNLLS	equilibrium rational expectations model assuming that $(m-m^*)$ and $(y-y^*)$ follows ARIMA (2.2.0) and ARIMA (2.1.0) processes, respectively.	"the results of the paper suggests that we are unable to accept...the equilibrium rational expectations model".
Levontakis (1987)	DM/US\$ 1974.1-1980.IV	s	$(m-m^*), (y-y^*), (i-i^*)$	OLS CQRC	also allows for lagged adjustments in real balances by including s_{t-1} as an explanatory variable. Also $(\pi-\pi^*)$ replaces $(i-i^*)$.	"the estimation of the flexible-price monetary model (...) generally do not provide support to the model".

- Notes:
- a- For a list of variables and symbols, see Appendix 1.
 - b- See list of abbreviations.
 - c- EM-excess money.
 - d- EER-log of effective exchange rate.

Table 4.2: Tests of the SPM for the 1970s and 1980s.

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variable	Estimation Technique ^b	Special Features	Results
Frankel (1979a)	DM/US\$ 1974.07-1978.02	s	$(m-m^*), (y-y^*), (p-p^*), (\pi, \pi^*)$	FAIR	$(\pi-\pi^*)$ proxied by long-rate government bond differential	"The evidence clearly support the model"
		s	$(m-m^*), (y-y^*), (i-i^*), (i-i^*)_{t-1}, (\pi-\pi^*)$	FAIR	Inclusion of lagged interest differential to account for not instantaneous adjustments in capital markets.	
Driskill (1981)	SF/US\$ 1973.03-1977.11	s	$(m-m^*), (m-m^*)_{t-1}, (p-p^*)_{t-1}$	OLS	Inclusion of two dummy variables (oil shock and demand for SF due to financial statements in Swiss firms).	Both models are satisfactory, but the constrained one is more supportive.
				MES	Estimation with constraints imposed.	
Haynes and Stone (1981)	DM/US\$ 1974.07-1978.02 1974.07-1980.04	s	$(m-m^*), (y-y^*), (i-i^*), (\pi-\pi^*)$	CORC	Reestimation of the Frankel (1979a)'s study.	For the shorter period the evidence is supportive, but not for the longer period.
		s	$m, m^*, y, y^*, i, i^*, \pi, \pi^*$	CORC	Allows for different coefficients for domestic and foreign explanatory variables	The model explains the exchange rate equally well for the 2 periods.
Driskill and Sheffrin (1981)		s	$(m-m^*), (y-y^*), (p-p^*), (\pi-\pi^*)$	OLS CORC	Elimination of $(i-i^*)$, since it is an endogenous variable.	"The results are not supportive of the theory".
		s	$(m-m^*), (y-y^*), (p-p^*)$	OLS	Elimination of expected inflation differential as an explanatory variable.	

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variable ^a	Estimation Technique ^b	Special Features	Results
Hacche and Towmend (1981)	UKP Effective Rate 1971.05-1980.02	ΔEER^*	$\Delta p, \Delta p_{t-1}, \Delta p^*,$ $\Delta p_{t-1}^*, \Delta y, \Delta y_{t-1},$ $\Delta y^*, \Delta y_{t-1}^*, \Delta m,$ $\Delta m_{t-1}, \Delta i^*, \Delta i_{t-1}^*,$ $\Delta EER_{t-1}, \Delta EER_{t-2}, \Delta PFO_{t-1},$ $(m+m-p^*)_{t-1}, y, i_{t-1}^*$	MES	Was of a general rational lag model an estimation imposing constraints. Inclusion of oil price variable (PFO) ^c	Poor support for the model.
Franke1 (1982 a)	DM/US\$ 1974.I - 1980.IV 1974.01-1980.11	s	$m, m^*, y, y^*, w, w^*,$ $(i-i^*), \pi, \pi^*$	OLS MES	Inclusion of wealth, in addition to income, as a transactions variable in money demand function.	"The monetary model with wealth included success in explaining the mark/dollar exchange rate during a period when the monetary approach without wealth and the portfolio approach both fail".
Frankel (1983)	DM/US\$ 1974.01-1980.12 DM/US\$ 1974.02-1980.11	s	$(m-m^*), y, y^*,$ $(i-i^*), \pi, \pi^*$	OLS CORC	π and π^* proxied by average inflation over preceeding 12 months.	The evidence tends "to support the general sticky-price form of the monetary model ... However, the insignificant ... coefficient on the money supplies and relative income continue to cast doubt on the monetary model in all forms".
		s	$(m-m^*), y, y^*,$ $(i-i^*), \pi, \pi^*$	FAIR		

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variable ^a	Estimation Technique ^b	Special Features	Results
McDonald (1983)	UKP/US\$ DM/US\$ CD/US\$ 1973.II - 1982.I	s	$m, m^*, (y-y^*), (i-i^*), (\pi, \pi^*)$	OLS COC FAIR	Instrumental variables: industrial WPI differential, $m_{t-1}, (y-y^*)_{t-1}$ and $(\pi-\pi^*)_{t-1}$.	Very poor estimates. "Respectable equations for the UK-US for the complete period... The application of the FAIR procedure to the German-US market makes little difference... However, the FAIR results for the CD are more encouraging".
	UKP/US\$ DM/US\$ CD/US\$ 1974.II-1977.IV	s	$(m-m^*), (y-y^*), (i-i^*), (\pi-\pi^*)$	OLS FAIR	To study if the equation is sensible to the period idem	Only the UKP/US\$ performs well for the period. Improvement in the CD/US\$ rate.
	UKP/US\$ DM/US\$ 1972/73-1982	s	$m_{t-1}(m-m^*), (m-m^*)_{t-1}, (p-p^*)_{t-1}, (y-y^*), (y-y^*)_t$	OLS	Driskill (1981)'s model	Only s_{t-1} is strongly significant. Evidence of overshooting.
Hacche and Towmed (1983)	US\$/UKP 1972.01-1977.10 1977.10-1981.12 1972.01-1981.12	s	$m, m^*, y, y^*, \pi, \pi^*, i, i^*$	MES	$(\pi-\pi^*)$ proxied by actual ratios of inflation and by long-term interest rate differential.	"The main features are the insignificance of the parameter estimates and their general instability; the apparent confirmation by the results for the 1st. sub-period, but the rejection by the 2nd., of the monetary model's predicted negative interest rate parameter ... (and) the limited impact made on the parameter estimates by the introduction of the lag polynomials on real exchange rate and relative velocity".
		s	$(m-m^*), (y-y^*), (\pi-\pi^*), (i-i^*), (v-v^*), q$	MES	Inclusion of velocity and real exchange rate.	

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variable ^a	Estimation Technique ^b	Special Features	Results
McDonald (1983)	UKP/US\$ DM/US\$ CD/US\$ 1973.11 - 1982.1	s	$m, m^*, (y-y^*), (i-i^*), (\pi, \pi^*)$	OLS CORC FAIR	Instrumental variables: industrial WPI differential, $s_{t-1}, (y-y^*)_{t-1}$ and $(\pi-\pi^*)_{t-1}$.	Very poor estimates. "Respectable equations for the UK-US for the complete period... The application of the FAIR procedure to the German-US market makes little difference... However, the FAIR results for the CD are more encouraging".
	UKP/US\$ DM/US\$ CD/US\$ 1974.11-1977.1V UKP/US\$ DM/US\$ 1972/73-1982	s	$(m-m^*), (y-y^*), (i-i^*), (\pi-\pi^*)$	OLS FAIR	To study if the equation is sensible to the period idem	Only the UKP/US\$ performs well for the period. Improvement in the CD/US\$ rate.
		s	$s_{t-1} (m-m^*), (m-m^*)_{t-1}, (p-p^*)_{t-1}, (y-y^*), (y-y^*)_{t-1}$	OLS	Driskill (1981)'s model	Only s_{t-1} is strongly significant. Evidence of overshooting.
Macche and Towmed (1983)	US\$/UKP 1972.01-1977.10 1977.10-1981.12 1972.01-1981.12	s	$m, m^*, y, y^*, \pi, \pi^*, i, i^*$	MES	$(\pi-\pi^*)$ proxied by actual ratios of inflation and by long-term interest rate differential.	"The main features are the insignificance of the parameter estimates and their general instability; the apparent confirmation by the results for the 1st. sub-period, but the rejection by the 2nd., of the monetary model's predicted negative interest rate parameter ... (and) the limited impact made on the parameter estimates by the introduction of the lag polynomial on real exchange rate and relative velocity".
		s	$(m-m^*), (y-y^*), (\pi-\pi^*), (i-i^*), (v-v^*), q$	MES	Inclusion of velocity and real exchange rate.	

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variable ^a	Estimation Technique ^b	Special Features	Results
Backus (1984)	CD/US\$ 1971.I-1980.IV	s	$(m-m^*), (y-y^*), (p-p^*)$	OLS	Dornbusch (1976)'s model.	"There is no evidence of overshooting ... we cannot reject the hypothesis for long-term monetary neutrality".
		s	$(m-m^*), (y-y^*), (p-p^*), (\pi, \pi^*)$	OLS	Driskill & Sheffrin (1981)'s version of Frankel (1979)'s model. Use of $(i_x - i_x^*)$ and $[(m-m^*)_{t-1}]$ as a proxy for $(\pi - \pi^*)$.	The model "performs well but probably for the wrong reason: the observed behavior of money supplies... is inconsistent with the theory".
		s	$\pi_{t-1}, (m-m^*), (m-m^*)_{t-1}, (p-p^*), (p-p^*)_{t-1}, (y-y^*), (y-y^*)_{t-1}, (\pi - \pi^*), (\pi - \pi^*)_{t-1}$	OLS	Driskill (1981)'s model with $(\pi - \pi^*)$ proxied by $(i_x - i_x^*)$.	"Fit substantially better than the other sticky-price models, largely owing to the presence of the lagged exchange rate ... No evidence of overshooting.
Frankel (1984)	DM/US\$ FF/US\$ UKP/US\$ JY/US\$ CD/US\$ 1974.02-1981.07	s	$(m-m^*), (y-y^*), (i - i^*), (\pi - \pi^*), (v-v^*), q$		Sticky-price monetary model with drift in velocity and real exchange rate.	"The empirical findings ... could be described as favorable".
Lafrance and Recette (1985)	CD/US\$ 1974.I-1980.IV	s	$(m-m^*), (y-y^*), (p-p^*), (\pi, \pi^*)$	OLS CORC	Driskill & Sheffrin (1981)'s version of Frankel (1979)'s model.	"The monetary approach is not acceptable".
		s	$\pi_{t-1}, (m-m^*), (m-m^*)_{t-1}, (y-y^*), (y-y^*)_{t-1}, (p-p^*)_{t-1}$	OLS	Driskill (1981)'s model.	The model "cannot be dismissed".
		s	$(m-m^*), (y-y^*), (\pi - \pi^*), (p-p^*), (w-w^*), (w-w^*)_{t-1}$	OLS	Inclusion of wealth in the demand for money assuming that $(w-w^*)$ follows an ARIMA (1,1,0) process	The model is "again rejected by the data even if we add a wealth effect in the relative demand for money".

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variable ^a	Estimation Technique ^b	Special Features	Results
Bajo (1986)	PTA/US\$ PTA/DM 1977.01-1983.12	s	$(m-m^*), (y-y^*), (p-p^*), (\pi, \pi^*)$	OLS CQRC FAIR	Inclusion of dummy variables for depreciations and seasonal adjustments. Also allows for different coefficients for domestic and foreign variables and inclusion of π_{t-1} .	Few coefficients are significant.
Bajo (1987)	PTA/US\$ PTA/DM 1977.01-1983.12	Δs	$\Delta(m-m^*), \Delta(y-y^*), \Delta(i-i^*), \Delta(\pi-\pi^*)$	OLS CQRC FAIR		"The estimation of the monetary model in first differences allows to overcome the autocorrelation problems that were present in the estimate in levels, as well as to improve noticeably its predictive power which is still inferior to the random walk model".

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Leventakis (1987)	DM:US\$ 1974.I-1980.IV	s	$(m-m^*), (y-y^*), (p-p^*)$	OLS CQRC	Dornbusch (1976)'s model.	Very poor results, no evidence of over-shooting.
		s	$(m-m^*), (y-y^*), (i-i^*), (\pi-\pi^*)$	OLS CQRC	Frankel (1979)'s model.	
		s	$(m-m^*), (y-y^*), (p-p^*), (\pi-\pi^*)$	OLS CQRC	Driskill & Sheffrin (1981)'s version of Frankel (1979)'s model.	
		s	$s_{t-1}^*, (m-m^*), (m-m^*)_{t-1}^*, (p-p^*), (y-y^*), (y-y^*)_{t-1}^*$	OLS	Driskill (1981)'s model. Also inclusion of $(w-w^*)$ as an explanatory variable, but the result does not substantially change.	"although the fit of the equation looks much better ... than the previous models, a closer examination of individual coefficients indicates that the stock-flow model is also questionable".
		s	$s_{t-1}^*, (m-m^*), (m-m^*)_{t-1}^*, (p-p^*), (p-p^*)_{t-1}^*, (y-y^*), (y-y^*)_{t-1}^*, (\pi-\pi^*), (\pi-\pi^*)_{t-1}^*$	OLS	Lafrance & Racette (1985)'s version of Driskill (1981)'s model.	"the results are not very supportive of the theory".

Notes: a. See Appendix I for a list of variables and symbols.

b. See list of abbreviations.

c. EER=log of effective exchange rate.

d. PFO=log of the effective US\$ price index of Saudi market crude oil.

in the last observations of the sample, as the subsequent results of Haynes and Stone (1981) confirm: the model is supported for the sample used by Frankel, but not by an augmented sample (1974.07-1980.04). Frankel himself in his 1983 paper concludes that there are some doubts about the appropriateness of the model to describe the 1974.02-1980.11 period. MacDonald (1983) finds little support for the model in explaining the UKP/US\$, DM/US\$ and CD/US\$ rates for the period 1973.II-1982.I, but he obtains some good estimates for the UKP/US\$ rate for the 1974.II-1977.IV period. Hacche and Townend (1983) find that the model is not very relevant in explaining the US\$/UKP rate for the 1972.06-1982.12 period. Bajo Rubio (1986) concludes that the model is rejected by the data of the PTA/US\$ and PTA/DM rates for the 1977.01-1983.12 period, but in Bajo Rubio (1987), he improves the estimations by taking first differences of the variables. Leventakis's (1987) estimation of Frankel's (1979) model leads to poor results.

Driskill and Sheffin (1981) respecification of Frankel's model to account for the endogeneity of the interest differential term, $(i-i^*)$ in equation (2.34) [i.e., equation (2.34a)] is not supportive of the model for the DM/US\$ rate during the period 1974.07-1978.02. Further attempts to estimate this version of the sticky-price monetary model by Backus (1984), Lafrance and Recette (1985), and Leventakis (1987) have reached similar conclusions.

Summarizing this empirical evidence, we can say that there is a break down in the empirical support for the monetary models around 1979.

4.2- POSSIBLE REASONS FOR THE FAILURE OF THE MONETARY MODELS.

4.2.1.- *Some Specification and Estimation Problems.*

The treatment of equations (2.6) and (2.7) as if they were reduced-form equations may be criticized on the grounds that real income and nominal interest rates are not truly exogenous but in fact are affected by the stock of money. Putman and Woodbury (1979) argue that real income is independent of the money supply since it is only the unanticipated growth in the money stock that has real effects. Therefore it seems reasonable to assume that the contemporaneous effect of unanticipated monetary growth on real income would be smaller for the monthly and quarterly observations usually used in the empirical work than for annual observations. With respect to the independence of the nominal interest rate, since the nominal interest rate can be viewed as the sum of the return to capital plus the expected rate of inflation, Putman and Woodbury assert that insofar as current monetary policy has no effect on current real income, the first component of the nominal interest rate will remain unaffected by the current money supply, and that the inflationary expectations component could be assumed to be also independent of current money supply. The independence of inflation expectations from the current money supply would be valid if such expectations were determined by an autoregression on past prices or by a rational expectations model which included lagged (but not current) values of the money supply.

Note also that equations (2.6) and (2.7) assume that the money demand elasticity with respect to income and the money demand semielasticity with respect to the interest rate are identical between countries. This allows us to combine the real income terms and the nominal interest rates forming differentials to avoid multicollinearity problems. Rasulo and Wilford (1980) argue that in the event that the elasticities are significantly different, a serious bias may be introduced by collapsing these variables, not only into the estimation of the collapsed term, but also into the coefficients of the other independent variables. They propose to estimate the following reduced-form equation:

$$s_t = (n^* - n) + (m_t - m_t^*) - \phi y_t + \phi^* y_t^* + \lambda i_t - \lambda^* i_t^*, \quad (4.1)$$

or, alternatively,

$$s_t = (n^* - n) + (m_t - m_t^*) - \phi y_t + \phi^* y_t^* + \lambda \Delta s_t^*. \quad (4.2)$$

Using these reduced-form equations, Rasulo and Wilford (1980) obtain more favourable results for the flexible-price monetary model for the US\$/UKP and US\$/IL rates during the 1973.I-1978.I and 1973.I-1976.II period, respectively. However, Backus (1984) does not obtain the same supportive results for the CD/US\$ rate for 1971.I-1980.IV period.

On the other hand, Haynes and Stone (1981) contend that empirical tests of exchange rate models based on equations (2.6) or (2.7) are inappropriate and misleading because the explanatory variables are specified in difference form (for example, the logarithmic difference between money supplies). Such subtractive linear constraints are especially dangerous because the specification bias which in general results from the restriction of terms leads to a sign reversal in the constrained coefficient. This follows because a reversal can be more likely, *ceteris paribus*, the stronger the direct correlation between the relevant domestic and foreign variables.

Estimation of equation (2.6) for the recent floating exchange rate period in which monetary authorities have intervened in the foreign exchange markets faces a potential simultaneous equation bias, since the domestic money supply term will be correlated with the error term (as will the foreign money supply), if the foreign monetary authorities intervene. A simple method of accounting for the simultaneity of the exchange rate and the money supply involves constraining the coefficient on $(m - m^*)$ to unity and estimating (4.3) instead of (2.6):

$$s_t - (m_t - m_t^*) = -a_{22}(y_t - y_t^*) + a_{23}(i_t - i_t^*). \quad (4.3)$$

Dornbusch (1980) assumes that the dependent variable $s - m + m^*$ follows a partial adjustment scheme and improves the specification of the money demand function by introducing a long-term interest rate as an additional opportunity cost variable. The resulting equation is

$$s_t - m_t + m_t^* = a_{21}(s_{t-1} - m_{t-1} + m_{t-1}^*) - a_{22}(y_t - y_t^*) + a_{23}(i_t - i_t^*) + a_{24}(i_{Lt} - i_{Lt}^*), \quad (4.4)$$

where $(i_L - i_L^*)$ is the long-term relative bond interest rate. The inclusion of two interest rates instead of one suggests that assets within each country with different term structures exert different influences on the demand for money¹⁴. Dornbusch's (1980) results fail to support the model, even for equation (4.4).

The same arguments about potential simultaneous equation bias apply to the reduced-form equations (2.29) and (2.34) derived from the sticky-price monetary model

4.2.2.- The PPP assumption.

A key factor in the failure of the flexible-price monetary model is the use of the purchasing power parity assumption in relating exchange rates and prices.

Although the examination of PPP for the interwar experience with floating exchange rates by Frenkel (1978) and Krugman (1978) gave evidence consistent with the that hypothesis, the tests of the absolute PPP for the recent floating suggest that purchasing power parity does not hold in the short run [see, e. g., Frenkel (1981), Miller (1984), Hakkio (1984) and Rush and Husted (1985)]. Even though this assumption is not essential for analyzing the role of monetary variables in influencing exchange rates [as Bilson (1979a) has proved by deriving equations (2.6) and (2.7) without explicit reference to purchasing power parity], it may be useful to allow explicitly for divergences from purchasing power parity.

Let us denote the ratio of foreign prices (expressed in domestic currency) to domestic prices (i.e., the real exchange rate) by $Q = SP^*/P$.

¹⁴ Note that this assumption should not violate the assumption that asset types between the two countries are perfect substitutes.

Absolute purchasing power parity assumes that Q equals unity on a systematic basis, which is the basis for equation (2.4). In general, however, $Q > 1$ if domestic prices, P , are lower than comparable foreign prices, SP^* , and $Q < 1$ if domestic prices exceed foreign prices converted into domestic currency. The relationship between the exchange rate and the relative price level can then be expressed by

$$S = QP/P^*,$$

or, taking logarithms,

$$s = q + p - p^*. \quad (4.5)$$

This modified version of the purchasing power parity hypothesis allows the exchange rate to diverge from the relative levels ($Q \neq 1$ or $q \neq 0$), but by a fixed margin, implying that Q is fixed over time. Combining equations (2.3) and (4.5), we obtain

$$s_t = (n^* - n) + (m_t - m_t^*) - \phi(y_t - y_t^*) + \lambda(i_t - i_t^*) + q. \quad (4.6)$$

Moreover, Clements and Frenkel (1980) argue that the assumption that the prices which are relevant for money markets are the same as those relevant for purchasing power parity can easily be relaxed by allowing the price level to be a weighted average of the nontradable and the internationally traded goods,

$$p = cp_N + (1-c)p_T, \quad (4.7)$$

$$p^* = cp_N^* + (1-c)p_T^*, \quad (4.8)$$

where p_N and p_T denote, respectively, the logarithm of prices of nontradable and tradable goods, and c denotes the weight of nontradable goods in the price index, and where we have assumed that $c = c^*$.

If purchasing power parity holds only for tradable goods, we replace equation (2.4) by (4.9)

$$s = p_T - p_T^*. \quad (4.9)$$

Using equations (4.7), (4.8) and (4.9) in (2.3) yields

$$s_t = (n^* - n) + (m_t^* - m_t) - \phi(y_t - y_t^*) + \lambda(i_t - i_t^*) + c((p_{Tt} - p_{Nt}) - (p_{Tt}^* - p_{Nt}^*)). \quad (4.10)$$

Equation (4.10) states that a rise in the domestic relative price of traded goods results in a depreciation of the currency, and that a rise in the foreign relative price of traded goods results in an appreciation of the currency. Note that the elasticity of the exchange rate with respect to the relative price should approximate c (the relative share of spending on non-traded goods). Since the Clements and Frenkel (1980) paper deals with the 1920s, it is not considered in Table 4.1. They conclude that "broadly, the results...are reasonably satisfactory" (p. 254).

Following Hsieh (1982), who assumed that

$$p_T = j - h_T, \quad (4.11a)$$

$$p_N = j - h_N, \quad (4.11b)$$

$$p_T^* = j^* - h_N^*, \quad (4.11c)$$

$$p_N^* = j^* - h_T^*, \quad (4.11d)$$

where h_T and h_N denote, respectively, the logarithm of average (and marginal) products of labor in the traded and nontraded industries, and where j is the logarithm of the nominal wage rate (measured in local currency), we can derive the following reduced-form equation for the exchange rate from equations (4.7), (4.8), (4.9) and (4.11),

$$s_t = c((h_N - h_T) - (h_N^* - h_T^*)) + (k^* - k) + (m_t^* - m_t) - \phi(y_t - y_t^*) + \lambda(i_t - i_t^*). \quad (4.12)$$

Hacche and Townend (1981) argue, on the other hand, that the role played by purchasing power parity would be better described by the

lagged adjustment of relative prices to exchange rates than by the lagged adjustment of exchange rates to relative price levels. This transmission mechanism suggests an alternative model, obtained by replacing (2.4) with:

$$p_t - p_t^* = \nu(s_t + p_{t-1}^* - p_{t-1}). \quad (4.13)$$

Substituting prices from (2.3), yields the following reduced-form for the exchange rate,

$$s_t = \left(\frac{1}{\nu} - 1 \right) (n_t^* - n_t) + \frac{1}{\nu} (m_t - m_t^*) - (m_{t-1} - m_{t-1}^*) - \phi (y_t - y_t^*) + \phi (y_{t-1} - y_{t-1}^*) + \lambda \left(\frac{1}{\nu} (i_t - i_t^*) - (i_{t-1} - i_{t-1}^*) \right). \quad (4.14)$$

4.2.3.- Money-demand specification.

Some authors have pointed out that the inability of recent studies to find empirical support for the monetary models may be due to the inappropriate specification of money demand functions.

Equations (2.1) and (2.2) assume that money markets clear instantaneously. There have been several attempts in the literature to allow for lags in money market adjustments. Following Goldfeld (1973), Bilson (1978a) specifies the following money-market equilibrium equation that allows actual money holdings to adjust slowly to the desired level, and in which the errors in the demand function follows a first-order moving-average scheme,

$$m_t - p_t = n_t + \phi y_t - \lambda i_t + \tau(m_{t-1} - p_{t-1}) + \rho u_{t-1} + u_t, \quad (4.15)$$

$$m_t^* - p_t^* = n_t^* + \phi y_t^* - \lambda i_t^* + \tau(m_{t-1}^* - p_{t-1}^*) + \rho u_{t-1}^* + u_t^*, \quad (4.16)$$

where u and u^* are independently-distributed random variables¹⁵, and where we have assumed that the demand for money functions for both countries have the same partial adjustment coefficient τ (τ is assumed to be positive and less than one). From these equations and from the purchasing power parity equation (2.4) and the uncovered interest parity

¹⁵ We can interpret u and u^* to be either technical innovation or portfolio disturbances.

equation (2.5), we can obtain, as Bilson does, the following exchange-rate equation that includes a lagged dependent variable and serial dependence in the error structure:

$$s_t^* = (n^* - n) + (m_t^* - m_t^*) - \phi(y_t^* - y_t^*) + \lambda \Delta s_t^* + \tau s_{t-1}^* + \rho \varepsilon_{t-1}^* + \varepsilon_t^*, \quad (4.17)$$

where $\varepsilon = u^* - u$.

For the sticky-price monetary model, by substituting equations (4.15) and (4.16) into equation (2.21), we replace equations (1.29) and (1.34) by similar equations which contain, in addition to the explanatory variables there considered, the lagged value of the exchange rate and a first-order moving-average [MA(1)] error term.

Bilson (1978b) allows for a trend in the shift factor of the money demand function, $n^* - n$, of the form

$$n^* - n = n_0 + \xi t \quad (4.18)$$

to account for the fact that the shift factor reflects some exogenous movements in the relative demand for the two currencies. Examples of factors responsible for such a change are the degree of uncertainty about the monetary and fiscal policies and the different rate of growth of the population of the countries under study. In (4.18), n_0 is a constant and ξ is the rate of growth in the relative money demand. Substituting (4.18) into (2.6) and (2.7), we obtain

$$s_t^* = (n^* - n) + (m_t^* - m_t^*) - \phi(y_t^* - y_t^*) + \lambda(i_t^* - i_t^*) + \xi t \quad (4.19)$$

and

$$s_t^* = (n^* - n) + (m_t^* - m_t^*) - \phi(y_t^* - y_t^*) + \lambda(\Delta s_t^*) + \xi t. \quad (4.20)$$

For the sticky-price monetary model, substituting (4.18) into (2.21) will result in the addition of the ξt term in (2.29) and (2.34).

Keran (1979) takes into account the length of time needed by market participants to recognize that the relative excess supplies of money have changed by introducing time lags in equation (2.6):

$$s_t = (k^* - k) + \sum_1^n z'_{t-n}, \quad (4.21)$$

where $z' = (m - m^*) - \phi(y - y^*) + \lambda(i - i^*)$ and \sum_1^n refers to the sum of months in which changes in excess money supplies will have their effect on the exchange rate. Similarly, for the sticky-price monetary model, we expand equations (2.29) and (2.34) by introducing lagged values of the relevant explanatory variables considered there.

Frenkel and Clements (1981) specify a richer formulation of the demand for money that recognizes that the spectrum of alternative assets and rates of return relevant for the specification of the demand for money is rather broad, including both rates of interest, i and i^* , as well as the forward premium on foreign exchange, Δs^e . They assume that the domestic demand for domestic money depends on domestic income and on alternative rates of return, according to

$$L_1 = n_1 Y^\phi \exp[-\lambda(i - i^*) - v\Delta s^e]$$

and that the foreign demand for domestic money is

$$L_1^* = n_1^* Y^{*\phi} \exp[-\lambda(i - i^*) - v\Delta s^e],$$

where the total demand for domestic money is $L_1 + L_1^* = L$. Analogously, the demand for foreign money is also composed of domestic demand for foreign money, L_2 , and foreign demand for foreign money, L_2^* , according to

$$L_2 = n_2 Y^\phi \exp[-\lambda(i - i^*) + v\Delta s^e],$$

and

$$L_2^* = n_2^* Y^{*\phi} \exp[-\lambda(i - i^*) + v\Delta s^e].$$

From the purchasing power parity, $S = P/P^*$, but the equilibrium in the money market implies that $P/P^* = (M/M^*)(L^*/L)$, so

$$\begin{aligned} S &= (M/M^*) \{ (L_2 + L_2^*) / (L_1 + L_1^*) \} \\ &= (M/M^*) \{ (n_2 Y^\phi + n_2^* Y^{*\phi}) / (n_1 Y^\phi + n_1^* Y^{*\phi}) \} \exp[2v\Delta s^e], \end{aligned}$$

or, taking logarithms,

$$s_t = (m_t - m_t^*) + \log(n_2 Y_t^\phi + n_2^* Y_t^{*\phi}) - \log(n_1 Y_t + n_1^* Y_t^{*\phi}) + 2v\Delta s_t^e. \quad (4.22)$$

Some authors have suggested that instability in demand for money functions may be responsible for the break-down of the monetary approach to exchange rate determination in the early 1980s (see for example Frankel (1981, 1982), Bilson (1979), and Smith and Wickens (1986)). Many money demand analysts believe that such instability is the result of the accelerating process of financial innovation, deregulation and international integration of world financial markets (see for example Goldfeld (1976), Judd and Scadding (1982), Laidler (1985), and Judd *et. al.* (1988))¹⁶. These factors tend to reduce the quantity of money demanded at given prices, incomes, and interest rates. Such a movement in the domestic money stock would suggest an appreciation in the domestic exchange rate according to the monetary models. However, as Boothe and Poloz (1988) point out, with prices unchanged, and assuming that PPP holds in the long run, no movement in the exchange rate would be forthcoming. Thus, shifts in demand for money functions translate directly into instability in monetary models of exchange rates. Boothe and Poloz (1988) try to accommodate the effects of such financial developments redefining money. By so doing, they obtain slight improvements in fit, but they have problems with coefficient signs and their data rejects the homogeneity predicted by the models.

There have also been some attempts to include wealth, in addition to income, as a transaction variable in the money demand function. Frankel (1982) assumes the following money market equilibrium conditions,

$$m_t - p_t = \phi y_t + \psi w_t - \lambda i_t \quad (4.25)$$

$$m_t^* - p_t^* = \phi^* y_t^* + \psi^* w_t^* - \lambda^* i_t^*. \quad (4.24)$$

From these equilibrium conditions he obtains the following exchange rate

¹⁶ An alternative explanation is the view of money as a "buffer stock" (see Goodhart, 1984).

equation

$$s_t = m_t - m_t^* - \phi y_t + \phi^* y_t^* - \psi w_t + \psi^* w_t^* + \lambda i_t - \lambda^* i_t^*. \quad (4.25)$$

Note that the asset market approach to exchange-rate determination places emphasis on the capital account of the balance of payments. However, the inclusion of wealth brings the current account back into exchange rate determination. A current account deficit will redistribute wealth from domestic to foreign residents, simultaneously raising foreign money demand, lowering domestic money demand, and raising the exchange rate. Frankel's (1982) results are very encouraging.

Following Frankel (1982), we can include a relative wealth term in the sticky-price monetary model through a wealth effect in the demand for money. From the money market equilibrium conditions (4.23) and (4.24), assuming for simplicity that the real balance demands are identical between countries (i.e., $\phi = \phi^*$, $\lambda = \lambda^*$ and $\psi = \psi^*$), we can replace equation (4.21) with (4.26)

$$(m_t - m_t^*) - (p_t - p_t^*) = \phi(y_t - y_t^*) - \lambda(i_t - i_t^*) + \psi(w_t - w_t^*) \quad (4.26)$$

in Frankel's system of behavioral equations (2.21), (1.5a) and (2.30). With the additional assumption that $(w - w^*)$ is not expected to change in the future, we can then obtain the following reduced-form equation for the exchange rate

$$s_t = (m_t - m_t^*) - (\phi + \gamma/\delta)(y_t - y_t^*) - (\psi + \gamma/\delta)(w_t - w_t^*) - \frac{1}{\delta}(i_t - i_t^*) + (\lambda \sigma/\delta + 1/\theta)(\pi_t - \pi_t^*). \quad (4.27)$$

Frankel's original estimates are very supportive of the model. On the other hand, Frankel (1984) allows for divergences from the purchasing power parity using the modified version (4.5) of equation (2.4) [reproduced here as (4.5a)], and he also introduces a drift in velocity in the money demand functions [equations (4.28) and (4.29)]:

$$\tilde{s} = \tilde{q} + \tilde{p} - \tilde{p}^*, \quad (4.5a)$$

$$\tilde{m} = \tilde{p} + \phi \tilde{y} - \lambda \tilde{i} + v_t, \quad (4.28)$$

$$\tilde{m}^* = \tilde{p}^* + \phi \tilde{y}^* - \lambda \tilde{i}^* + v_t^*, \quad (4.29)$$

where \sim denotes long-run equilibrium. Using these equations in Frankel's (1979) system of equations, we have

$$s_t = (m_t - m_t^*) - (\phi + \gamma / \delta)(y_t - y_t^*) - 1 / \delta (i_t - i_t^*) \\ + (\lambda + \sigma / \delta + 1 / \theta)(\pi_t - \pi_t^*) + (v_t - v_t^*) + q_t. \quad (4.30)$$

The empirical evidence about this reduced-form equation is mixed: Frankel (1984) finds significant support for it, but Hacche and Townend (1983) do not find much support.

Lafrance and Racette (1985) assume that $(w - w^*)$ follows an ARIMA(1,1,0) process and obtain the following equation for Frankel's (1979) model with wealth

$$s_t = a_{31}(m_t - m_t^*) + a_{32}(y_t - y_t^*) + a_{33}(p_t - p_t^*) + a_{34}(\pi_t - \pi_t^*) \\ (1) \quad (?) \quad (-) \quad (+) \\ + a_{35}(w_t - w_t^*) + a_{36}(w_{t-1} - w_{t-1}^*), \quad (4.31) \\ (-) \quad (+)$$

where the expected values or signs of the coefficients are denoted in parentheses and where $a_{31} + a_{33} = 1$.

Neither Lafrance and Racette (1985) nor Leventakis (1987) obtain results that support the theory.

4.2.4.-The role of equity markets.

Another reason for the divergence of the exchange-rate predictions of the monetary models from actual exchange rates is the omission of trends in equity markets.

As Chinn (1989) argues, the greater integration of equity markets, that has led to a greater link between these markets and international financial flows, means that equity markets have an increasing influence on exchange rates. This influence can help to explain some excess variability in foreign exchange markets, since equity markets have a

tendency to develop significant pricing errors [see, e. g., Shiller (1981) and Campbell and Shiller (1987)].

We can introduce the role of equity markets in exchange-rate determination by reformulating the uncovered interest-parity equation (2.5) as follows

$$\Delta s_t^e = s_{t+1}^e - s_t^e = (1-\zeta)(i_t - i_t^*) + \zeta(i_{kt} - i_{kt}^*), \quad (4.32)$$

where i_k is one period return on equities. In equation (4.32) we have assumed that investors apply a weighting to equity and bond returns such that the expected depreciation equals a weighted average of the interest and holding period return differentials.

Substituting $(i - i^*)$ from (4.32) into (2.6) we obtain the following revised specification of the flexible-price monetary model:

$$s_t = (n - n^*) + (m_t - m_t^*) - \phi(y_t - y_t^*) + \lambda / (1 - \zeta) \Delta s_t^e - \lambda \zeta / (1 - \zeta) (i_{kt} - i_{kt}^*). \quad (4.33)$$

Similarly, by substituting the amended uncovered interest-parity equation (4.32) for equation (2.5a) in Frankel's system of behavioral equations; we obtain the following reduced-form equation for the exchange rate

$$s_t = (m_t - m_t^*) - \phi(y_t - y_t^*) - \frac{(1-\zeta)}{\theta} (i_t - i_t^*) - \frac{\zeta}{\theta} (i_{kt} - i_{kt}^*) + (\lambda + \frac{1}{\theta}) (\pi - \pi^*). \quad (4.34)$$

4.2.5.- The perfect substitutability assumption.

A last explanation for the failure of the monetary models is the questionable assumption of perfect substitutability between assets denominated in different currencies. We will consider the extensions derived by relaxing this assumption in Section 6, where we study the different endeavors to integrate the monetary and portfolio-balance approaches to exchange-rate determination.

4.1.6.-Evaluating the relative importance of the causes of failure of the monetary models.

Smith and Wickens (1986) attempt to provide measures of the relative importance of the principal causes of failure of the monetary models by including an additional term in each structural equation to represent any misspecification and by estimating the extra contribution of these variables compared with the original restricted reduced form equation for the exchange rate. This information, they argue, can be used to help determine how to respecify the system in such a way that it has the maximum benefit for the reduced form of particular interest.

By estimating various restricted versions of the general stochastic model in which all the structural errors are represented, they confirm the importance of the breakdown of the PPP assumption, but they also show that misspecification of the money market is equally important.

4.2.- THE EQUILIBRIUM RATIONAL EXPECTATIONS MODEL.

The empirical evidence of the *Equilibrium Rational Expectations model* (EREM) is represented in Table 4.1 by to kind of different results. On the one hand, Hoffman and Schlagenhauf (1983) obtain *supportive* results for the US\$/DM, US\$/FF and US\$/UKP rates for the 1974.06-1982.10 period, assuming that the exogenous variables follow ARIMA(1,1,0) processes. On the other hand, Backus (1984) achieves *poor* results for the CD/US\$ exchange rate for the 1971.I-1980.IV period, assuming that the explanatory variables follow AR(1) and AR(2) processes, as do Gámez-Amián and Navarro-Gómez (1986) for the Spanish Peseta effective exchange rate during the 1973.07-1981.09 period, using the Box-Jenkins (1970) methodology to identify the processes followed by the explanatory variables.

Woo (1985) extends the EREM to include partial adjustment in the demand for money functions as specified in equations (4.15) and (4.16). Combining these equations with equations (2.5), (2.10) and (2.12) the following reduced-form exchange rate equation can be obtained

$$s_t = (1+\lambda)^{-1} z'_t + \tau(1+\lambda)^{-1} s_{t-1} + \lambda(1+\lambda)^{-1} E_t s_{t+1}, \quad (4.35)$$

where $z'_t = (n^* - n)_t + (m - m^*)_t - \phi(y - y^*)_t - \tau(m - m^*)_{t-1} - (u - u^*)_t$. Rearranging terms gives

$$(1+\lambda)^{-1} E_t s_{t+1} - s_t + \tau(1+\lambda)^{-1} s_{t-1} = -\lambda(1+\lambda)^{-1} z'_t \quad (4.36)$$

On taking expectations through (1.36) conditioned on information generally available at time $t-1$ we obtain

$$(1+\lambda)^{-1} E_{t-1} [E_t s_{t+1}] - E_{t-1} s_t + \tau(1+\lambda)^{-1} E_{t-1} s_{t-1} = -\lambda(1+\lambda)^{-1} E_{t-1} z'_t,$$

or

$$(1+\lambda)^{-1} E_{t-1} s_{t+1} - E_{t-1} s_t + \tau(1+\lambda)^{-1} s_{t-1} = -\lambda(1+\lambda)^{-1} E_{t-1} z'_t. \quad (4.37)$$

A solution for equation (4.37) can be obtained following Wickens (1985). Using the forward operator F , where $F^j x_t = E_t x_{t+j}$, we can write the characteristic equation of (4.37) as

$$\lambda F^2 - (1+\lambda)F + \tau = 0$$

which has the solution

$$\xi = \frac{\sqrt{(1+\lambda) \pm (1+\lambda)^2 - 4\tau\lambda}}{2\lambda}.$$

Denoting the two roots ξ_1 and ξ_2 , Wickens shows that they satisfy $\xi_1 < 1$ and $\xi_2 > 1$ (i.e., the solution is a saddle point).

Equation (4.37) can then be rewritten as

$$\lambda(F - \xi_1)(F - \xi_2)s_{t-1} = -E_{t-1}z'_t,$$

so that

$$-\lambda\xi_2 F(1 - \xi_1 F^{-1})(1 - \xi_2^{-1}F)s_{t-1} = -Fz'_{t-1},$$

and therefore

$$(1 - \xi_1 F^{-1})Fs_{t-1} = -Fz'_{t-1} / [\lambda\xi_2 - \xi_2^{-1}F].$$

From this last equation s_t can be expressed as follows

$$s_t = \xi_1 s_{t-1}^{-1} / (\lambda\xi_2) \sum_{j=0}^{\infty} \xi_2^{-j} E_t z'_{t+j}. \quad (4.38)$$

On taking expectations through (4.38) conditional on information available at time $t-1$ we obtain

$$E_{t-1} s_t = \xi_1 s_{t-1}^{-1} / (\lambda\xi_2) \sum_{j=0}^{\infty} \xi_2^{-j} E_{t-1} z'_{t+j}. \quad (4.39)$$

From the definition of rational expectation it follows that

$$s_t = E_{t-1} s_t + \varepsilon_t, \quad (4.40)$$

where ε_t is the innovation in s_t with respect to information dated $t-1$. Hence, combining (4.40) and (4.39) the solution of equation (4.37) is given by

$$E_{t-1} s_t = \xi_1 s_{t-1}^{-1} / (\lambda\xi_2) \sum_{j=0}^{\infty} \xi_2^{-j} E_{t-1} z'_{t+j} + \varepsilon_t. \quad (4.37')$$

Woo (1985) estimates (4.37') jointly with a vector autoregressive model (VAR) of the exogenous variables z' , obtaining supportive results for the reformulated EREM.

5.- THE PORTFOLIO-BALANCE MODEL: EMPIRICAL EVIDENCE AND EXTENSIONS

5.1.- REDUCED-FORM ECONOMETRIC EVIDENCE.

An important problem faced by researchers applying this model is the absence of data on holdings of financial assets by currency of denomination. In practice, most studies have used cumulated current account balances (from some benchmarks) of the two countries concerned as proxies for the net bilateral supplies of foreign assets.

Table 5.1 summarizes some empirical tests of the Portfolio-Balance Model during the 1970s and 1980s. As in the case of the monetary models, around 1979 there is a break down in the explanatory power of the model.

The empirical estimation of equation (3.5) is represented in Table 5.1 by Branson, Haltunnen, and Masson (1977), Branson and Haltunnen (1979), and Martin and Masson (1979). They adjust the cumulated current account surpluses for cumulated official intervention, and in estimation attempt to allow for simultaneous determination of intervention policy. While the first study finds reasonable support for the model, the second study obtains mixed results, depending on currencies and periods, and the last one rejects the model.

Bisignano and Hoover (1980) consider also the supplies of domestic and foreign government interest-bearing debt as an explanatory variable, and find strong confirmation of the portfolio-balance model for three of the four currencies they study. In their 1982 paper the results are not so supportive of the model.

Further attempts to estimate this original version of the portfolio-balance model are represented in Table 5.1 by Backus (1984) and Leventakis (1987). Both studies reject the model for the exchange rates and periods considered.

The empirical evidence for the Frankel's (1983) version of the portfolio-balance model is very poor.

Table 5.1: Tests of the PBM for the 1970s and 1980s.

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Branson, Halttunen, and Masson (1977)	US\$/DM 1971.08-1976.12	S	M, M*, A, A*	OLS CORC	A proxied by cumulated CA balances on benchmark observations, minus holdings of central banks.	"all the coefficients have the expected signs".
		S	M, M*, A, A*	2SLS	Exchange rate equation estimated simultaneously with a policy reaction function for intervention.	"the estimates look reasonable and support the asset market model".
Branson and Halttunen (1979)	US\$/DM US\$/JY DM/FF DM/SF DM/UKP 1971.08-1976.06 1973.04-1976.06	s	m, m*, a, a*	OLS CORC	Similar proxy for A.	Mixed results depending on currencies and periods.
Martin and Masson (1979)	CD/US\$ JY/US\$ 8 Currencies 1973.04-1978.04					"the empirical verdict on the utility of the portfolio-balance model ...must be judged unfavorable".
Bisignano and Hoover (1980)	US\$/DM US\$/JP US\$/IL US\$/CD 1973.03-1978.12	S	M, B, A, M*, B*, A*	OLS CORC FAIR		Strong confirmation of the portfolio-balance model for US\$/CD. The US\$/UKP provides only modest support for the model.
Bisignano and Hoover (1982)	US\$/CD 1973.03-1978.12	S	RM ^C , B, A, i*	OLS CORC FAIR		Almost all the variables have the correct sign, but only one is significant.

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Frankel (1983)		s	$(1-f)^*$, b, b [*]	OLS CORC	Residents in both countries have uniform asset preferences	"the results are very poor for the portfolio-balance model. The coefficients on all four stock variables are always of the incorrect sign and usually appear significantly so".
		s	$(1-f)^*$, b, a	OLS CORC	US bonds hold only by US residents.	
		s	$(1-f)^*$, b [*] , a [*]	OLS CORC	German bonds hold only by German residents.	
		s	$(1-f)^*$, b, b [*] , a, a [*]	OLS CORC	General case.	
Frankel (1984)	DM/US\$ FF/US\$ UKP/US\$ CD/US\$ 1974.02-1984.07	S	B, B [*] , W, W [*]	CORC		"though the own assets and wealth variables are significant for some of the countries, the results are as poor as those for the monetary equation".

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Backus (1984)	CD/US\$ 1972.I-1980.IV	S and s	M, B, A, i^*, y	OLS		"the obvious inference is that the model is wrong".
		S	M, B, A_{t-1}, i^*, y	OLS	Dynamic version.	
Leventakis (1987)	DM/US\$ 1974.I-1980.IV	S	M, B, A, i^*	OLS CORG FAIR	Current values of exogenous variables and lagged values of exogenous and endogenous variables as instrument variables.	"coefficients are significant, but only has the expected signs".
		S	M, A, M^*, i^*	OLS		"all coefficients are significant, but only the coefficient on A has the expected sign".
				CORG FAIR		"two of the coefficients retain their significance, but only the coefficient of A has the correct sign".

Notes: a. For a list, of variables and symbols, see Appendix I.

b. See list of abbreviations.

c. RM is reserve money.

5.2.- INTRODUCING EQUITY MARKETS.

Following Sarantis (1987), we can expand Branson's model by introducing equity assets into the portfolio of investors. The structural equations of the model are now as follows

$$M_t = \mu(i_t, i_{Kt}, i_t^*) W_t, \quad (5.1)$$

$$B_t = \beta(i_t, i_{Kt}, i_t^*) W_t, \quad (5.2)$$

$$K_t = \kappa(i_t, i_{Kt}, i_t^*) W_t, \quad (5.3)$$

$$S_t A_t = \alpha(i_t, i_{Kt}, i_t^*) W_t, \quad (5.4)$$

$$W_t \equiv M_t + B_t + K_t + S_t A_t, \quad (5.5)$$

where K is the nominal stock of domestic equity assets, κ is the desired fraction of wealth held as equity assets, and i_K is the domestic nominal interest rate (or yield) on equity assets.

In the short run, the asset stocks (M , B , K , and A) are predetermined. If we assume that the domestic economy is small relative to the foreign economy (i. e., i^* is fixed exogenously), given the identity (5.5), only three of the four equations (5.1) to (5.4) are independent. These determine the exchange rate, S , and the domestic interest rates, i and i_K .

The reduced-form equation for the exchange rate is then

$$S_t = \varphi'_1 + \varphi'_2 M_t + \varphi'_3 B_t - \varphi'_4 K_t - \varphi'_5 A_t - \varphi'_6 i_t^*. \quad (5.6)$$

As for the case of an increase in domestic bond stock, the effect of an increase in domestic equity stock on the exchange rate is ambiguous, depending on the relative substitutability among domestic assets versus domestic and foreign assets.

6.-THE SYNTHESIS OF THE MONETARY AND PORTFOLIO-BALANCE EQUATIONS.

6.1.- THEORETICAL MODELS.

The monetary models, which assume that the short-run risk premium is zero or that assets denominated in different currencies are perfect substitutes in the short run, will present misspecification problems if there is imperfect substitutability of assets in the short run and hence the existence of a risk premium. On the other hand, the portfolio-balance model, that allows for imperfect substitutability between assets denominated in different currencies, is also likely to be misspecified unless it incorporates expectations.

There have been attempts by a number of researchers to improve on estimates of the reduced-form monetary and portfolio-balance equations by combining features of both models into a reduced-form equation of exchange-rate determination (see for example Isard (1980), Hooper and Morton (1980), Frankel (1983, 1984), and Hacche and Townend (1983)). Bisignano and Hoover (1980) develop a real rate augmented monetary equation of short-run exchange-rate determination that takes into account portfolio balance considerations by assuming (a) that short-run deviations from the long-run equilibrium exchange rate [equation (2.4)] are caused by deviations in real interest rates, r and r^* ,

$$s_t - \tilde{s} = -\gamma(r_t - r_t^*), \quad (6.1)$$

where \tilde{s} is the long-run equilibrium exchange rate, determined by relative prices; and (b) that in the short run the real interest rate is determined by the ratio of outside bonds to outside money, χ ,

$$r = \Lambda(\chi). \quad (6.2)$$

Combining (6.1) and (6.2) with (2.3) and (2.4), we have

$$s_t = (n^* - n) + (m_t^* - m_t) - \phi(y_t - y_t^*) + \lambda(i_t - i_t^*) - \gamma(\chi_t - \chi_t^*), \quad (6.3)$$

where we use χ as a proxy of the real interest function given by (6.2). Bisignano and Hoover (1980) obtain a substantial improvement in

the goodness of fit by replacing equation (2.6) with equation (6.3) (See Table 6.1).

An interesting variant of the sticky-price monetary model is developed by Driskill (1981). His stock-flow model generalizes the Dornbusch (1976) model by permitting imperfect substitutability between foreign and domestic assets and by allowing trade flows to affect financial markets through the balance of payments. He replaces the uncovered-interest-parity condition (2.5a) in the Dornbusch framework with the balance-of-payments equation

$$A_t - A_{t-1} = T_t, \quad (6.4)$$

where A is the net demand for foreign assets and T is the trade balance. Demand for foreign assets is specified as a function of expected net yields:

$$A_t = \eta[s_{t+1}^e - s_t - (i_t - i_t^*)], \quad (6.5)$$

and the trade balance is assumed to be a linear function of the logarithm of relative prices and the logarithm of relative incomes:

$$T_t = \omega[s_t - (p_t - p_t^*)] + \psi(y_t - y_t^*). \quad (6.6)$$

Therefore, by substituting (6.5) and (6.6) into (6.4), we can express the balance of payments as follows

$$\eta(E_t s_{t+1} - s_t - (i_t - i_t^*)) - A_{t-1} = \omega[s_t - (p_t - p_t^*)] + \psi(y_t - y_t^*). \quad (6.4a)$$

If we assume that the relative money supply follows a random walk, equation (2.26) becomes

$$E_t s_{t+1} - s_t = \theta[(m_t - m_t^*) - s_t]. \quad (6.7)$$

Combining (6.7) and (6.4a), we have

$$\eta[\theta[(m_t - m_t^*) - s_t] - (i_t - i_t^*)] - A_{t-1} = \omega[s_t - (p_t - p_t^*)] + \psi(y_t - y_t^*),$$

or, solving for s ,

$$s_t = \left\{ \frac{\eta\theta}{(\omega+\eta\theta)} \right\} (m_t - m_t^*) - \left\{ \frac{\eta}{(\omega+\eta\theta)} \right\} (i_t - i_t^*) + \left\{ \frac{\omega}{(\omega+\eta\theta)} \right\} (p_t - p_t^*) \\ + \left\{ \frac{\Psi}{(\omega+\eta\theta)} \right\} (y_t - y_t^*) - \left\{ \frac{1}{(\omega+\eta\theta)} \right\} A_{t-1}.$$

Substituting for $(i_t - i_t^*)$ from (2.15a), we obtain

$$s_t = \left\{ \frac{(\eta\theta + \eta/\lambda)}{(\omega+\eta\theta)} \right\} (m_t - m_t^*) + \left\{ \frac{(\Psi - \eta\phi/\lambda)}{(\omega+\eta\theta)} \right\} (y_t - y_t^*) \\ + \left\{ \frac{(\omega - \eta/\lambda)}{(\omega+\eta\theta)} \right\} (p_t - p_t^*) - \left\{ \frac{1}{(\omega+\eta\theta)} \right\} A_{t-1}. \quad (6.8)$$

On the other hand, by substituting (2.15a) and (6.7) into (6.5), we have

$$A_t = \eta\theta[(m_t - m_t^*) - s_t] - \frac{1}{\lambda}[\phi(y_t - y_t^*) - (m_t - m_t^*) + (p_t - p_t^*)],$$

or, lagging this expression one period, and using the result to eliminate A_{t-1} in (6.8), we obtain

$$s_t = \left\{ \frac{(\eta\theta)}{(\omega+\eta\theta)} \right\} s_{t-1} + \left\{ \frac{(\eta\theta + \eta/\lambda)}{(\omega+\eta\theta)} \right\} [(m_t - m_t^*) - (m_{t-1} - m_{t-1}^*)] \\ + \left\{ \frac{(\omega - \eta/\lambda)}{(\omega+\eta\theta)} \right\} (p_t - p_t^*) + \left\{ \frac{(\eta/\lambda)}{(\omega+\eta\theta)} \right\} (p_{t-1} - p_{t-1}^*) \\ + \left\{ \frac{(\Psi - \eta\theta/\lambda)}{(\omega+\eta\theta)} \right\} (y_t - y_t^*) - \left\{ \frac{(\eta\theta/\lambda)}{(\omega+\eta\theta)} \right\} (y_{t-1} - y_{t-1}^*).$$

Finally, assuming further that $(y_t - y_t^*)$ is a random walk, we obtain

$$s_t = \left\{ \frac{(\eta\theta)}{(\omega+\eta\theta)} \right\} s_{t-1} + \left\{ \frac{(\eta\theta + \eta/\lambda)}{(\omega+\eta\theta)} \right\} [(m_t - m_t^*) - (m_{t-1} - m_{t-1}^*)] \\ + \left\{ \frac{(\omega - \eta/\lambda)}{(\omega+\eta\theta)} \right\} (p_t - p_t^*) + \left\{ \frac{(\eta/\lambda)}{(\omega+\eta\theta)} \right\} (p_{t-1} - p_{t-1}^*) \\ + \left\{ \frac{\Psi}{(\omega+\eta\theta)} \right\} (y_t - y_t^*). \quad (6.9)$$

From equations (2.22) and (2.21a), the reduced form for the expected difference between prices can be written as

$$E_t(p_{t+1} - p_{t+1}^*) = \delta s_t + (1 - \delta - \sigma/\lambda)(p_t - p_t^*)$$

$$+(\gamma-\sigma\phi/\lambda)(y_t-y_t^*)+\sigma/\lambda(m_t-m_t^*). \quad (6.10)$$

Driskill lags this equation to substitute for $(p-p^*)$ in (6.9) and obtains the following expression

$$\begin{aligned} s_t = & \{(\eta\theta+\delta(\omega-\eta/\lambda))/(\omega+\eta\theta)\}s_{t-1} + \{(\eta/\lambda)/(\omega+\eta\theta)\}(m_t-m_t^*) \\ & + \{[(\omega-\eta/\lambda)\theta/\lambda-\eta/\lambda]/(\omega+\eta\theta)\}(m_{t-1}-m_{t-1}^*) \\ & + \{[(1-\delta-\sigma/\lambda)\sigma/\lambda+(\psi-\eta\phi/\lambda)]/(\omega+\eta\theta)\}(p_{t-1}-p_{t-1}^*) + \{\Psi/(\omega+\eta\theta)\}(y_t-y_t^*) \\ & + \{[(\gamma-\sigma\phi/\lambda)(\omega-\eta/\lambda)]/(\omega+\eta\theta)\}(y_{t-1}-y_{t-1}^*). \end{aligned} \quad (6.11)$$

The model provides somewhat different predictions from the Dornbusch and Frankel specifications. Long-run neutrality still holds (the coefficients of s , $(m-m^*)$, and $(p-p^*)$ at various lags sum to one), but overshooting is no longer necessary. The crucial parameter is η : with perfect substitutability between domestic and foreign assets (infinite η), the coefficient of $(m-m^*)$ exceeds one, but for finite values, the initial response of s to a monetary shock may exceed or "undershoot" its long-run response.

Driskill (1981) obtains satisfactory estimates of this version of Frankel's (1979) model, while Hacche and Townend (1981), Lafrance and Racette (1985), and Leventakis (1987) conclude that the validity of this version of the model is questionable.

Hooper and Morton (1982) modify the Dornbusch-Frankel model to allow for a shift in the long-run equilibrium real exchange rate and the existence of a risk premium. The equilibrium exchange rate is defined as the rate that is consistent today with current and expected future values of its underlying determinants. To derive such determinants we can divide the equilibrium nominal rate into its relative price and real components:

$$\tilde{s} = (\tilde{p}-\tilde{p}^*) + \tilde{q}. \quad (6.12)$$

From the home and foreign money market equilibrium conditions, we can obtain the equilibrium relative prices [equation (2.32), reproduced here as (6.13)] assuming that the interest differential equals the inflation differential in equilibrium:

$$(\tilde{p}-\tilde{p}^*)=(\tilde{m}-\tilde{m}^*)-\phi(\tilde{y}-\tilde{y}^*)+\lambda(\tilde{\pi}-\tilde{\pi}^*). \quad (6.13)$$

The equilibrium real exchange rate (\tilde{q}) is defined by Hooper and Morton as the rate that equilibrates the current account in the long run. To simplify the model they assume that the expected future change in the real exchange rate is zero, so that \tilde{q} shifts over time only in response to unexpected developments about the current account. Therefore,

$$\tilde{q}_t - \tilde{q}_{t-1} = -(1/\zeta)(CA_t - E_{t-1} CA_t), \quad (6.14)$$

where CA denotes the current account balance.

Summing (6.14) over time yields

$$\tilde{q}_t = \tilde{q}_0 - (1/\zeta) \sum_{i=0}^t (CA_{t-i} - E_{t-i-1} CA_{t-i}). \quad (6.15)$$

Equation (6.15) states that the equilibrium real exchange rate in period t is a function of an initial equilibrium rate, \tilde{q}_0 , and the cumulative sum of past non-transitory unexpected changes in the current account balance.

To close the model Hooper and Morton replace the uncovered interest parity condition (2.5a) in the Frankel's sticky-price monetary model with an augmented version that allows for imperfect substitutability of assets

$$\Delta s^e = i_t - i_t^* + \Gamma, \quad (6.16)$$

where Γ represents the risk premium attached to the addition of foreign investment to asset portfolios in the absence of covering.

Substituting (6.15) into the rational expectation equation (2.31) and solving for s , we get

$$s_t = \tilde{s} - (1/\theta)((i_t - \tilde{\pi}) - (i_t^* - \tilde{\pi}^*) - \Gamma). \quad (6.17)$$

Finally, substituting (6.16) and (6.32) into (6.12) and the result into (6.17), and assuming that current equilibrium values of money supplies, income levels and inflation rates are given by their current actual values, yields

$$s_t = (m_t - m_t^*) - \phi(y_t - y_t^*) + \lambda(\pi_t - \pi_t^*) + \tilde{q}_0 - (1/\zeta) \sum_{i=0}^t \{CA_{t-i} - E_{t-1-i} CA_{t-i}\} \\ - (1/\theta)((i_t - \pi_t) - (i_t^* - \pi_t^*) - \Gamma). \quad (6.18)$$

Equation (6.18) expresses the spot exchange rate as a function of the relative money, income and inflation rates as determinants of equilibrium relative prices; cumulative movements in the current account, as determinants of the equilibrium real exchange rate; and the real interest rate differential and the risk premium. In equation (6.18) an increase in the risk premium (induced by a decline in current account or official intervention in the exchange market) leads to a depreciation of the domestic currency. This formulation may be viewed as a general form in which both the flexible-price and the sticky-price monetary models are special cases.

By integrating the monetary models, as presented by equation (6.19), with the portfolio-balance model, as presented in equation (6.20), Frankel (1983) suggest an alternative synthetic model that can be represented by equation (6.21),

$$s_t = (m_t - m_t^*) - \phi(y_t - y_t^*) + \lambda(i_t - i_t^*) - 1/\theta[(i_t - \pi_t) - (i_t^* - \pi_t^*)] \quad (6.19)$$

$$s_t = b_t - a_t - k - l[i_t - i_t^* - \Delta s_t^*] \quad (6.20)$$

$$s_t = \{k/(1+\theta l)\} + \{\theta l/(1+\theta l)\}(m_t - m_t^*) - \{\theta l\phi/(1+\theta l)\}(y_t - y_t^*) \\ + \{l(\theta\lambda+1)/(1+\theta l)\}(\pi_t - \pi_t^*) - \{l/(1+\theta l)\}(i_t - i_t^*) \\ + \{1/(1+\theta l)\}(b_t - a_t). \quad (6.21)$$

Since equation (6.21) contains the monetary and portfolio-balance models as special cases, it provides a framework for evaluating them

empirically.

Following Sarantis (1987), Nguyen and Chiang (1989) suggest yet another way of combining elements of both the monetary and portfolio-balance approaches. In order to introduce a long-run equilibrium exchange-rate into Branson *et al.*'s model, Sarantis replaces i^* with i^f in the equilibrium asset markets equations (5.1) to (5.3) and introduces two additional equations into the structural equations of the model:

$$i_t^f = i_t^* + \Delta S^e \quad (6.22)$$

and

$$\Delta S^e = \Omega(S - \tilde{S})/S_t, \quad \Omega > 1. \quad (6.23)$$

Equation (6.22) states that the return on foreign assets, i^f , is equal to the foreign interest rate, i^* , plus the expected depreciation of the domestic currency, ΔS^e . Equation (6.23) postulates that the latter is generated by a regressive expectations mechanism, where \tilde{S} is the long-run exchange rate.

From the structural equations (5.1) to (5.5) (as amended), (6.22) and (6.23), Sarantis obtains the following equations for the exchange rate (S) and interest rate on domestic bonds (i):

$$S_t = S(M, B, K, A, i^*, \tilde{S}) \quad (6.24)$$

and

$$i_t = i(M, B, K, A, i^*, \tilde{S}), \quad (6.25)$$

where $S_M > 0$, $S_B < 0$, $S_K < 0$, $S_A < 0$, $S_{i^*} > 0$, $S_{\tilde{S}} > 0$, $i_M < 0$, $i_B > 0$, $i_K > 0$, $i_A = 0$, $i_{i^*} < 0$, and $i_{\tilde{S}} > 0$.

Nguyen and Chiang (1989) integrate the flexible-price monetary model into the above framework by assuming that equation (2.6) holds in the long run. Without imposing any specific functional form, they write this assumption as follows:

$$\tilde{S} = \tilde{S}(M/M^*, Y/Y^*, i, i^*), \quad (6.26)$$

where $\tilde{S}_{M/M^*} > 0$, $\tilde{S}_{Y/Y^*} < 0$, $\tilde{S}_i > 0$, and $\tilde{S}_{i^*} < 0$, and where the long-run values of monetary supplies, income levels, and interest rates are taken to be the same as the current-period values.

Substitution of (6.26) into (6.24) yields

$$S_t = S'(M, B, K, A, i^*, M/M^*, Y/Y^*), \quad (6.27)$$

where $S'_M > 0$, $S'_B > 0$, $S'_K > 0$, $S'_A < 0$, $S'_{i^*} > 0$, $S'_{M/M^*} > 0$, and $S'_{Y/Y^*} < 0$.

Finally, let us consider an extension of the portfolio-balance model that introduces foreign asset accumulation through the balance of payments. Prominent examples include Kouri (1976) and Dornbusch and Fischer (1980). In the simplest version all bonds are perfect substitutes. A discrete-time version is given by

$$M_t(i_t^* + E_t S_{t+1} - S_t, Y_t, M_t + B_t + S_t A_t) = M_{t-1} \quad (6.28)$$

$$T_t(S_t, Y_t, M_t + B_t + S_t A_{t-1}) = S_t(A_t - A_{t-1}). \quad (6.29)$$

Equation (6.28) is simply the monetary equilibrium condition with interest parity, and the demand for money assumed to be dependent on the interest-rate differential between domestic and foreign bonds, on real income (Y), and on start-of-period wealth. Equation (6.29) is the balance-of-payments equation. Typically, the trade balance depends positively on the exchange rate, and negatively on real income and start-of-period wealth. The lags of A result from taking a discrete-time analog of a continuous-time model.

A linear approximation of (6.28) and (6.29) around a stationary point $E_t S_{t+1} = S_t = \tilde{S} = 1$ and $A_t = A_{t-1} = \tilde{A}$ is

$$\begin{pmatrix} M_1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} dE_t S_{t+1} \\ dA_t \end{pmatrix} = \begin{pmatrix} -M_1 + \tilde{M}_3 A & M_3 \\ T_1 + (T_3 + i_t^*) \tilde{A} & 1 + (T_3 + i_t^*) \end{pmatrix} \begin{pmatrix} dS_t \\ dA_{t-1} \end{pmatrix} + \begin{pmatrix} (1-M_3) dM_t - M_3 dB_t - M_1 di_t^* - M_2 dY_t^* \\ -T_3 dM_t - T_3 dB_t - A di_t^* - T_2 dY_t \end{pmatrix}, \quad (6.30)$$

where $dZ = Z - \tilde{Z}$ for any variable Z . The stationary point is a saddle point. The long-run equilibrium exchange rate depends on the forcing variables, which are assumed not to change:

$$\tilde{S}_t = \tilde{S}'(M_t, B_t, i_t^*, Y_t), \quad (6.31)$$

where $S'_M > 0$, $S'_B = 0$, and $S'_Y > 0$. The long-run effect of i^* is ambiguous, and depends on the ratios of interest effects to wealth effects in money demand and in the current account. $S'_i > 0$ if $A/T_3 > M_1/M_3$.

The short-run solution is derived by assuming that

$$E_t S_{t+1} - S_t = \Xi(\tilde{S}_t - S_t), \quad (6.32)$$

where Ξ is one minus the stable root of (6.30). Substituting (6.32) into (6.28) yields to

$$S_t = \tilde{S}_t + [\Xi(M_1 - M_3)A]^{-1}[(M_3 - 1)dM_t + M_3 dB_t + M_3 dA_{t-1} + M_1 di_t^* + M_2 dY_t^*]. \quad (6.33)$$

Finally, \tilde{S} can be eliminated using (6.31).

If $M_1 - M_3 < 0$, the solution

$$S_t = S''(M_t, B_t, A_{t+1}, Y_t) \quad (6.34)$$

has partial derivatives $S''_M > 0$, $S''_B = S''_A < 0$. There is overshooting in the sense that $S''_M > \tilde{S}_M$. If \tilde{S}'_i is positive, then S''_Y is also positive. The income effect is ambiguous since the long-run and the short-run effects are of opposite sign.

6.2.- ECONOMETRIC EVIDENCE.

Table 6.1. reports estimates of some of the synthetic equations we have just reviewed.

The empirical evidence from Hooper and Morton's (1982) synthesis is supportive in their original study for the U.S. Dollar effective rate during the 1973.II-1978.IV and 1973.03-1978.12 periods, but leads to disappointing results for the Sterling Pound effective rate during the 1977.II-1981.II period [Hacche and Townend (1983)] and for three major rates during the 1973.II-1982.I period [MacDonald (1983)].

Frankel's (1983) does not find support for his synthetic model using data for the US\$/DM rate during the 1974.01-1978.10 period. Nor does Frankel's (1984) study of five major exchange rates for the 1974.02-1981.07 period.

Table 6.1: Tests of the SPMM for the 1970s and 1980s.

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Hacche and Townend (1981)	UKP Effective rate 1972.05-1980.02	ΔEER^C	$\Delta(m-m^*), \Delta(y-y^*), \Delta(i-i^*),$ $PFO \Delta[(i-\pi)-(i^*-\pi^*)]$	ALS FAIR	because of highly significant positive serial correlation, the results are in first-differenced form. Use of a price oil variable and allow for different coefficients for domestic and foreign variables	"the results are unfortunately quite different from Frenkel's and are inconclusive".
Hoyer and Morton (1982)	US\$ effective rate 1973. 11-1978.IV 1973. 03-1978. 12	EER	$(m-m^*), (y-y^*), (\pi-\pi^*),$ $[(1-\pi)-(1-\pi^*)] CA$	OLS IV		"the results...generally conform to our theoretical priors".
Frankel (1983)	USS/DM 1974. 01-1978.10	s	$(m-m^*), (y-y^*), (i-i^*),$ $(\pi-\pi^*), (b-b^*)$	OLS CONC	uniform asset preferences among residents of all countries.	"the coefficients of the variables from the monetary equation..."
		s	$(m-m^*), (y-y^*), (i-i^*),$ $(\pi-\pi^*), (b-a)$	OLS CONC	"domestic-small country" assumption.	are usually correct in sign. However, when we correct for serial correlation, most of them lose their significance. The coefficients of relative bond supply in the uniform preference and German small country versions, appear significant but of the reverse sign for that hypothesized in the portfolio-balance approach."
		s	$(m-m^*), (y-y^*), (i-i^*),$ $(\pi-\pi^*), (b-a)$	OLS CONC	"foreign-small country" assumption.	
Hacche and Townend (1981)	UKP Effective rate 1977.11 1981.11	EER	$(m-m^*), (y-y^*), (\pi-\pi^*),$ $[(1-\pi)-(1-\pi^*)]$ CA. PFO	ALS	Hooper & Morton (1982)'s model. Also addition of an oil price variable	disappointing results

Study	Currencies and Period	Dependent Variable ^a	Relevant Explanatory Variables ^a	Estimation Technique ^b	Special Features	Results
Mac Donald (1983)	UKP/US\$ DM/US\$ CD/US\$ 1973.II-1982.I	s	$(m-m)^*$, $(y-y)^*$, $(i-i)^*$, $(\pi-\pi)^*$, CA	CORC	Hooper & Morton (1982)'s model	"none of the variables is significantly different from zero, many are wrong signed and a few have the correct magnitude"
Frankel (1984)	DM/US\$ FF/US\$ UKP/US\$ JY/US\$ CD/US\$ 1974.02-1981.07	s	$(m-m)^*$, $(y-y)^*$, $(i-i)^*$, $(b-w)^*$, $(w-w)^*$, $(\pi-\pi)^*$, $(w-w)^*$	CORC	Frankel (1983)'s synthesis	"the results are surprising... But one cannot claim that the synthesis works better than the sum of the parts, because the coefficients on the variables from the monetary model are almost invariably insignificant".
Levantakis (1987)	DM/US\$ 1974.1-1980.IV	s	$(m-m)^*$, $(y-y)^*$, $(i-i)^*$, $(\pi-\pi)^*$ CA	OLS CONC	Hooper & Morton (1982)'s model	the coefficients are either insignificant or wrongly signed.
		s	$(m-m)^*$, $(y-y)^*$, $(i-i)^*$, $(\pi-\pi)^*$ CAU	OLS CONC	Hooper & Morton (1982)'s model replacing CA by the accumulative deviation of CA from trend balances (CAU)	"the model is not supported by the data"

Notes: a. See Appendix I for a list of variables and notation.

b. See list of abbreviations.

c. EER-log of effective exchange rate

d. w^w is the log of the world wealth.

7. -THE OUT-OF-SAMPLE FORECASTING PERFORMANCE OF SOME REDUCED FORM ASSET MODELS.

We have so far considered only the within-sample fit of the reduced form asset models summarized in Tables 4.1, 4.2, 5.1 and 6.1. A stronger test of the validity of a model is to determine its out-of-sample forecasting performance. Among the most influential empirical studies of exchange-rate forecasting models are those of Meese and Rogoff (1983a, 1983b, 1985), which we describe below.

Meese and Rogoff (1983a) compare both time series and asset models of exchange rates on the basis of their post-sample forecasting accuracy. The reduced form equations they test are the flexible-price monetary model [equation (2.6)], Frankel's (1979) version of the sticky-price monetary model [equation (2.34)], and Hooper and Morton's (1982) portfolio-monetary synthesis equation (6.18) with zero risk premium ($\Gamma=0$). The time series models they consider are the random walk model, the forward exchange rate, a univariate autoregression of the spot rate and an unconstrained vector autoregression of the exchange rate on all the explanatory variables in equation (3.6) plus cumulated domestic and foreign trade balances. The study is conducted for the US\$/UKP, US\$/DM, US\$/JY and trade-weighted U.S.Dollar exchange rate using data from March 1973, the beginning of the floating, to June 1981. Initially, the models are estimated using data through the first forecasting period, November 1976, and forecasts are generated at horizons 1, 3, 6 and 12 months. Then, the December data are added to the sample, the parameters are updated, and new forecasts are generated for the four time horizons. This recursive process continues until forecasts are generated using June 1981 data. Forecasting accuracy is measured by three summary statistics that are based on standard symmetric loss functions: the mean error (ME), the mean absolute error (MAE), and the root mean square error (RMSE), defined as

$$ME = \sum_{j=0}^{N_k-1} \left[s_{t+j+k}^F - s_{t+j+k}^A \right] / N_k, \quad (7.1)$$

$$MAE = \sum_{j=0}^{N_k-1} |s_{t+j+k}^F - s_{t+j+k}^A| / N_k, \quad (7.2)$$

$$RMSE = \left\{ \sum_{j=0}^{N_k-1} [s_{t+j+k}^F - s_{t+j+k}^A]^2 / N_k \right\}^{1/2}, \quad (7.3)$$

where $k = 1, 3, 6, 12$ denotes the forecast step, N_k the total number of forecasts in the projection period for which the actual value s_t^A is known, and s_t^F the forecast value. Forecasting begins in period t . Because we are looking at the log of the exchange rate, these statistics are unit free (they are approximately percentages) and comparable across currencies. Table 7.1 reproduces Meese and Rogoff's results, where the reduced forms of the asset models are estimated using Fair's (1970) instrumental variables technique to correct for first order serial correlation. From Table 4.1 we conclude that none of the asset reduced forms considered out-perform the naive random walk model at any forecasting horizon shorter than 12 months¹⁷. This result is all the more striking since the reduced form forecasts are based on the actual realized values of the explanatory variables¹⁸ and the coefficients of the model are permitted to vary depending on the true forecast horizon adopted. Thus, two of the greatest difficulties in using structural models to produce forecasts are eliminated in the Meese and Rogoff estimation of forecasting efficiency.

In a further paper, Meese and Rogoff (1983b) consider some possible explanations for the failure of the reduced form asset models to out-perform the random walk model post-sample forecasts. In particular, They show, using the vector autoregression methodology, that the instruments used in simultaneous equations estimated of asset reduced forms may not be truly exogenous and thus that the estimated reduced forms may be extremely imprecise. To overcome this problem Meese and

¹⁷ The failure of the univariate time series models to beat the random walk model is similarly robust.

¹⁸ This suggests that "news" about market fundamentals appears to be of little value in predicting nominal exchange rates. However, there is still the possibility of some types of news difficult to quantify, such as political events, financial crises, and central bankers' views of equilibrium exchange rates.

Table 7.1.-Root mean square forecast errors (RMSEs).

Model:		Random	FPMM	SPMM	H-P
		Walk			
Exchange Rate	Horizon				
US\$/DM	1 month	3.72	3.17	3.65	3.50
	6 months	8.71	9.64	12.03	9.95
	12 months	12.98	16.12	18.87	15.69
US\$/JY	1 month	3.68	4.11	4.40	4.20
	6 months	11.58	13.38	13.94	11.94
	12 months	18.31	18.55	20.41	19.20
US\$/UKP	1 month	2.56	2.82	2.90	3.03
	6 months	6.45	8.90	8.88	9.08
	12 months	9.96	14.64	13.66	14.57
Trade-weighted Dollar	1 month	1.99	2.40	2.50	2.74
	6 months	6.09	7.07	6.49	7.11
	12 months	8.65	11.40	9.80	10.35

Source: Meese and Rogoff (1983a, p.13).

Rogoff impose coefficient constraints, based on theoretical and empirical studies of the demand for money and purchasing power parity, on the asset reduced forms and re-estimate the RMSEs for the same period as Meese and Rogoff (1983a). Interestingly, while they confirm that the forecasting performance of the coefficient-constrained asset models is not superior to that of the random walk model for horizons up to 12 months, their findings do suggest that these models sometimes out-perform the random walk model when the forecasting horizon is longer than a year (which was not possible because of degrees of freedom problems with unrestricted estimates in Meese and Rogoff, 1983a). As Salemi (1984) points out, this tends to suggest that the spot exchange rate behaves like a pure asset price in the short term (i. e., approximately as a random walk) but in the longer term its equilibrium value is systematically related to other economic variables, as the asset models predict. Meese and Rogoff (1983b) suggest that the poor

post-sample performance of the asset reduced forms may reflect a misspecification of the demand for money, the influences of a variable risk premium, volatile real exchange rates, unsatisfactory measures of inflation expectations or a combination of these.

Meese and Rogoff (1985) extend the analysis of their first two papers to consider non-U.S. Dollar exchange rates (DM/JY and DM/UKP), real exchange rates as well as nominal exchange rates (US\$/DM, US\$/JY, and US/UKP), and an extra three years of data for the post-sample forecasting period in order to cover the Reagan regime period November 1980-June 1984. They also improve their methodology by implementing a new test of out-of-sample fit that is valid even for overlapping long-horizon forecasts. They conclude that their results are "slightly more favorable than the results of our earlier studies" (p. 18). They find that the sticky-price monetary model does do better than the naive random walk model for the US\$/JY and DM/UKP exchange rates and that the Hooper and Morton (1982) synthesis improves on the random walk model for the US\$/UKP and DM/UKP exchange rates at all horizons.

After Meese and Rogoff's seminal papers, there have been a number of attempts to evaluate the ex-post forecasting performance of structural exchange rate models which we now examine. Backus (1984) tests various versions of both flexible-price and sticky-price monetary models as well as portfolio-balance models for the CD/US\$ exchange rate over the 1970s. His results are qualitatively identical to those of Meese and Rogoff (1983a). Several endeavours have also been made to account for mis-specification of the money demand function as a possible explanation for the poor post-sample forecasting performance. For example, Woo's (1985) reformulated version of the EREM [to include Goldfeld's (1973) type of partial adjustment in demand for real balances] out-performs the random-walk model in predicting the US\$/DM exchange rate during the forecasting period from March 1980 through October 1981. A similar exercise is conducted for the US\$/UKP exchange rate for the period January 1980 to December 1982 by Finn (1986), who attributes the good forecasting performance of the model to the explicit, and therefore more accurate, allowance for the dynamics of the explanatory variables. Hogan (1986) considers the forecasting accuracy

of static and dynamic specifications of both flexible-price and sticky-price models, the latter motivating lagged adjustment considerations. He studies the AD/US\$ exchange rate over the period September quarter 1981 to the December quarter 1984. Hogan concludes that the dynamic specification of the sticky-price monetary model generates forecasts superior to the random walk model. Somanathan (1986) extends the dynamic specification to all three models considered by Meese and Rogoff (1983a, 1983b) as well as to Frankel's (1982) flexible-price monetary model with financial wealth as a determinant of the exchange rate [equation (4.25)] and Branson *et. al.*'s (1977) portfolio-balance model [equation (3.5a)]. Somanathan's results for the DM/US\$ exchange rate for various forecasting periods show that the consideration of lagged adjustment can contribute towards better out-of-sample forecasting performance.

The possibility of parameter variation over time has also been considered as an explanation of why the reduced form asset models fail to beat the random walk model out of sample. Wolff (1987) uses varying-parameter estimation techniques based on recursive application of the Kalman filter to improve the predictive performance of the models considered by Meese and Rogoff (1983a). He points out factors such as instability in the conventional money demand functions employed in the structural models, the occurrence of changes in policy regimes (Lucas (1976)) and factors leading to changes in the real exchange rate (changes in oil prices, global trade patterns, etc), could lead to parameter instability in the reduced form equations. Wolff studies the same set of exchange rates as Meese and Rogoff (1983a) for the period March 1973 to April 1984. He finds that allowing estimated parameters to vary over time enhances the forecasting performance of the models for the US\$/UKP, US\$/DM, and US\$/JY exchange rates, the post-sample forecasts for the US\$/DM exchange rate being better than those obtained from the random walk. Schinasi and Swamy (1989) conduct a similar exercise applying a general technique for estimating stochastic coefficients (described in Swamy and Tinsley, 1980) that encompasses as a special case the Kalman filtering technique and extend the analysis to include also dynamic specifications of the models considered by Meese and Rogoff (1983a). They support Wolff's (1987) conclusions.

8.- EXCHANGE RATES AND THE ROLE OF "NEWS".

In recent years the distinction between anticipated and unanticipated movements in exchange rates and its explanatory variables has been emphasized in the literature (see for example Dornbusch (1980), Frenkel and Mussa (1980), Frenkel (1981), Isard (1983), and Mussa (1984)). The basis for that emphasis is the efficient market approach.

The original concept of an efficient market is due to Fama (1965) who defined such a market as "a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants" (p. 56). Thus, in an efficient market security prices at any time should fully reflect all available information.

In the foreign exchange market, if the participants are rational and risk neutral, expectations concerning future rates should be incorporated and reflected in forward exchange rates. Thus the forward exchange rate should be an unbiased predictor of the future spot rate. Hence a regression of the observed spot rate at time t on the forward rate determined at time $t-1$ (where exchange rates are measured by natural logarithms of currency prices of foreign exchange),

$$s_t = \alpha + \beta f_{t-1}^t + u_t \quad (8.1)$$

should result in an estimated constant ($\hat{\alpha}$) not significantly different from zero, an estimated coefficient on the forward rate ($\hat{\beta}$) not significantly different from one, and serially uncorrelated errors (u_t).

However, although the forward rate is an unbiased predictor of the spot rate, it is not a particularly good predictor [see, e. g., Hodrick (1987)].

Frenkel (1983) argues that changes in expectations between the time that the forward rate prediction is made and the spot rate is observed

explain the forward error. These changes in expectations, which he calls "news", are based on information revealed after the forward contracts are made, but before the spot rates are realized.

There have been several attempts to examine the role of the "news" in exchange rate determination. The key difficulty has lain in identifying the variable which measures "news". Dornbusch (1980) distinguishes news of three kinds: news about the current account, cyclical or demand factors, and interest rates; Frenkel (1983) assumes that the news is immediately reflected in (unexpected) changes in interest rates; Bomboff and Korteweg (1983) generate news about money supplies using the Kalman filter method; and MacDonald (1983) generates news about the interest rates using the Box-Jenkins (1970) methodology.

Following Hoffman and Schlagenhauf (1985), we consider a wider set of variables in news form by using the different exchange-rate models we have reviewed in previous sections. Thus, from equation (1.2), the traditional flow model suggests that unanticipated changes in the spot exchange rate should be correlated with unanticipated changes in relative income, unanticipated movements in relative prices, and unanticipated changes in the interest rate differential:

$$s_t - f_{t-1}^t = g[(y_t - y_t^*) - E_{t-1}(y_t - y_t^*), (p_t - p_t^*) - E_{t-1}(p_t - p_t^*), \\ (i_t - i_t^*) - E_{t-1}(i_t - i_t^*)]. \quad (8.2)$$

From Section 1, we expect $g_{(y-y^*)} > 0$, $g_{(p-p^*)} > 0$, and $g_{(i-i^*)} < 0$, since a surprise increase in relative real income or in relative prices will cause agents to revise upwards their spending on foreign goods and, therefore, to expect a worse current account balance and a domestic currency depreciation; but an unexpected increase in the interest rate differential will cause agents to expect capital inflows and an appreciation of the exchange rate.

From the Frenkel-Mussa-Bilson model, we have that the appropriate form of the unanticipated changes in exchange rates is either

$$s_t - f_{t-1}^t = g[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*), (y_t - y_t^*) - E_{t-1}(y_t - y_t^*), \\ (i_t - i_t^*) - E_{t-1}(i_t - i_t^*)], \quad (8.3)$$

from equation (2.6), or,

$$s_t - f_{t-1}^t = g[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*), (y_t - y_t^*) - E_{t-1}(y_t - y_t^*), \\ (\pi_t - \pi_t^*) - E_{t-1}(\pi_t - \pi_t^*)], \quad (8.4)$$

from equation (2.7).

From Section 2.1.1, we can assume that $g_{(m-m^*)} > 0$, $g_{(y-y^*)} < 0$, $g_{(i-i^*)} > 0$, for equation (8.3) since unexpectedly rapid domestic relative money growth or an unexpected rise in the domestic interest rate will cause agents to revise upward their expectations of inflation if they do not think that the domestic monetary authorities will completely offset this shock. Higher expected domestic inflation will, all else constant, result in a depreciation of the domestic currency. On the other hand, unexpectedly rapid domestic (relative) real growth will induce the agents to revise upward their expectations of domestic real growth, and therefore they will also revise upward their expectations on the demand for domestic money. Hence they will expect the domestic currency to appreciate.

The news version of the Dornbusch (1976) sticky-price monetary model [equation (2.29)] can be written as

$$s_t - f_{t-1}^t = g[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*), (p_t - p_t^*) - E_{t-1}(p_t - p_t^*), \\ (y_t - y_t^*) - E_{t-1}(y_t - y_t^*)]. \quad (8.5)$$

Since a surprise increase in relative real activity or a surprise increase in prices will be taken by agents as a signal of future inflation, it will have a depreciating effect on the domestic currency, and therefore we expect that $g_{(p-p^*)} > 0$ and $g_{(y-y^*)} > 0$. On the other hand, a surprise increase in money supply will cause agents to expect a fall in the interest rate (since prices are sticky in the short term) and an

appreciation of the domestic currency in foreign exchange markets. Hence, we expect that $g_{(m-m)^*} < 0$.

From equation (2.34), we can write the news form of the Frankel (1979) sticky-price monetary model as

$$s_t - f_{t-1}^t = g[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*), (y_t - y_t^*) - E_{t-1}(y_t - y_t^*), \\ (i_t - i_t^*) - E_{t-1}(i_t - i_t^*), (\pi_t - \pi_t^*) - E_{t-1}(\pi_t - \pi_t^*)], \quad (8.6)$$

where we expect that $g_{(m-m)^*} > 0$, $g_{(y-y)^*} < 0$, $g_{(i-i)^*} < 0$, and $g_{(\pi-\pi)^*} > 0$, since we now have that an unexpected increase in relative money supply or in relative inflation will lead to unexpected depreciation in the exchange rate, while an unexpected increase in real activity or in the interest rate differential will lead to an unexpected appreciation in the exchange rate.

From the portfolio-balance model's reduced-form equation (3.5), we have that unanticipated changes in the spot exchange rate can be expressed as

$$S_t - F_{t-1}^t = g[(M_t - E_{t-1}M_t, B_t - E_{t-1}B_t, A_t - E_{t-1}A_t, i_t^* - E_{t-1}i_t^*)], \quad (8.7)$$

where, from the analysis in section 3.4, we expect $g_M > 0$, $g_B < 0$, $g_A < 0$, and $g_{i^*} < 0$.

Finally, from Frenkel's (1983) synthetic equation (5.21), we can write the news version of the synthetic model as

$$s_t - f_{t-1}^t = g[(m_t - m_t^*) - E_{t-1}(m_t - m_t^*), \\ (y_t - y_t^*) - E_{t-1}(y_t - y_t^*), (i_t - i_t^*) - E_{t-1}(i_t - i_t^*), \\ (\pi_t - \pi_t^*) - E_{t-1}(\pi_t - \pi_t^*), (b_t - a_t) - E_{t-1}(b_t - a_t)], \quad (8.8)$$

where we expect that $g_{(m-m)^*} > 0$, $g_{(y-y)^*} < 0$, $g_{(i-i)^*} < 0$, $g_{(\pi-\pi)^*} > 0$, and $g_{(b-a)} < 0$.

9.- CONCLUDING REMARKS.

Since the advent of relatively free-floating exchange rates in the early 1970s, a vast literature on exchange rate modelling has developed. Considerable progress has been achieved in identifying forces of importance for the advancement of our understanding of the determination of exchange rates. On the one hand, the monetary approach to exchange rate determination, in contrast to the traditional view, has made a significant contribution in emphasizing the role of financial transactions in producing exchange rate changes. This approach suggests that exchange rate changes result from stock disequilibrium emanating from the money market, rather than from the flow of receipts and payments arising from international trade. The monetary approach has also revived interest in the purchasing power parity (PPP) theory, stimulating an important debate on the nature of this theory. On the other hand, the portfolio-balance approach has underlined the significance of supplies of and demands for a wide range of different currency denominated assets in exchange rate determination, besides stressing the role of the current account in distributing wealth across countries.

In this paper we have reviewed the theoretical models associated with those approaches, focusing on the implied reduced-form equations.

We have also examined the empirical evidence on these models for the recent floating period, finding that econometric evidence on these models is mixed and inconclusive: they seem to work, to some extent, for the first period of the recent floating experience (i. e., 1975-1978), but they do not work so well in the 1980s. In addition, studies by Meese and Rogoff (1983a, b) have indicated that the explanatory power of econometric exchange rate models has been extremely poor. They conclude that models of exchange rates could not perform better than a naive random-walk model in the post sample forecasting tests, even when the explanatory variables used were the realized values during the post

sample period.

This so-called breakdown of the asset-market models was variously attributed to invalid cross-country restrictions, simultaneous equation bias, sampling error, and mis-specification of the underlying money demand functions.

Given that the empirical exchange rate literature does not give much comfort to any particular exchange-rate model, some of these models were extended by incorporating suggestions that have been previously fragmented in the literature, and synthetic equations that integrate elements of both the monetary and portfolio-balance approaches were proposed.

Finally, given the perception of the exchange rate as dependent on expectations concerning the future course of events (and, therefore, as very responsive to "news"), and the fact that a salient feature of the 1970s and 1980s has been the continuous stream of new information about variables such as money supply, interest rates and inflation, we presented the implementation of the exchange-rate models in a "news" context.

APPENDIX: ABBREVIATIONS

AD	Australian Dollar
CD	Canadian Dollar
CORC	OLS with Cochrane-Orcutt procedure to adjust for serial correlation
DM	Deustchemark
EREM	Equilibrium Rational Expectation Model
FAIR	Fair's Instrumental Variables
FF	French Franc
FIML	Full Information Maximun Likelihood
FPMM	Flexible-Price Monetary Model
HL	Hildreth-Lu method to obtain iterative CORC estimates
IV	Instrumental Variables
JY	Japanese Yen
MES	Mixed Estimation (OLS imposing constraints)
MFM	Mundell-Fleming Model
OLS	Ordinary Least Squares
PBM	Portfolio-Balance Model
PPP	Purchasing Power Parity
PTA	Spanish Peseta
RMSE	Root Mean Square Error
SF	Swiss Franc
SPMM	Sticky-Price Monetary Model
SYNM	Synthesis of the Monetary and Portfolio Models
TFM	Traditional-Flow Model
2SLS	Two Stage Least Squares
3SNLLS	Thre Stage Non-Linear Least Squares
UKP	Pound Sterling
US\$	U. S. Dollar
VAR	Vector Autoregressive

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